TRANSPORTATION DESIGN MANUAL

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1.1 GENERAL

This section provides guidelines on the functional classifications of roadways and their respective geometric design criteria.

1.2 CLASSIFICATION OF ROADWAYS

The classification of roadways into functional classes and geometric configurations is necessary for communication among administrators, engineers, and the general public. In addition, street classification categorizes roadways based on their function.

1.3 FUNCTIONAL CLASSIFICATION

There are six roadway classifications: alleys, residential streets, collector streets, arterial streets, freeways, and parkways. These classifications provide a hierarchy of roadways for an overall transportation network. Figure 1-1 shows a schematic of a street network. Figure 1-2 shows the relationship of roadway classification to access and mobility. Functional classification for each street shall be identified upon the time of submittal of preliminary plans. The following section describes functional characteristics for each roadway classification.

1.3.1 ALLEY

An alley is a passageway designed primarily to provide access to or from the rear or side of property otherwise abutting on a public street.

1.3.2 RESIDENTIAL STREET

The primary function of a residential street is to serve abutting land uses and traffic within a neighborhood or residential district. A residential street is not generally continuous through several districts.

1.3.3 COLLECTOR STREET

The primary function of a collector street is to intercept traffic from intersecting residential streets and expedite the movement of this traffic in the most direct route to an arterial street or other collector street. Collector streets are further classified into residential, neighborhood, commercial, and industrial collectors:

1.3.3.1 Residential Collector*:* The primary function of a residential collector is to collect traffic within a residential district and is not intended to continue through several districts. These streets generally provide on-street parking. Such streets provide access within a subdivision adjacent to single family and multifamily uses.

1.3.3.2 Neighborhood Collector: The primary function of a neighborhood collector is to serve several subdivisions or districts. These streets provide limited access to abutting properties. On-street parking is limited on these streets. Typically multifamily developments, schools, local retail developments and public facilities are located adjacent to neighborhood collector streets.

1.3.3.3 Commercial Collector*:* The primary function of a commercial collector is to serve as principal access to commercial developments. Large vehicles such as delivery trucks utilize these streets. Driveway access is limited to accommodate higher traffic volumes and larger vehicles. On-street parking is generally limited or restricted on these streets. Multifamily developments can front on these roads, provided adequate off-street parking is available.

1.3.3.4 Industrial Collector: The primary function of an industrial collector is to serve as principal access to industrial developments. Large vehicles such as WB-50s utilize these streets, thereby requiring greater area for circulation and movement. Driveway access is limited to accommodate higher traffic volumes and larger vehicles. On-street parking is generally limited or restricted on these streets. Multifamily developments can front on these roads, provided adequate off-street parking is available.

1.3.4 Arterial Street

Arterial streets are designed to carry high volumes of through traffic. Access is usually limited to intersections and major driveways. Arterial streets serve as a link between major activity centers within the urban area.

1.3.4.1 Minor Arterial: A minor arterial is a street whose main purpose is to serve as a major route through and between centers in urban areas. Typically, neither parking nor access to residential uses are permitted.

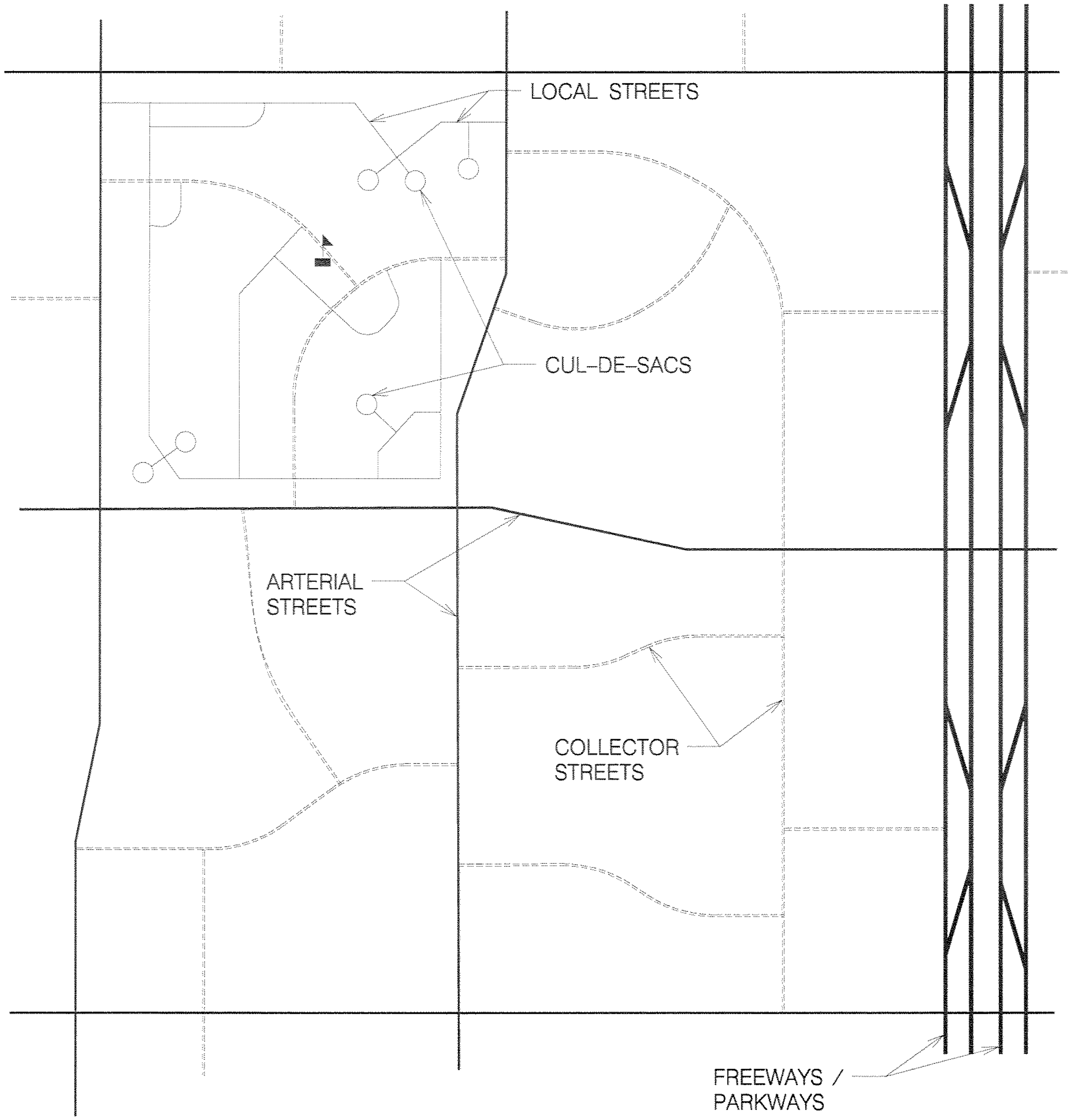
1.3.4.2 Major Arterial: A major arterial is a street, including Interstate Highway Service Roads, whose main purpose is to serve as a major route into, out of, or across an urban area. Typically neither parking nor access to residential uses is permitted.

1.3.5 Parkway

A parkway is a freeway, which does not have continuous frontage roads. Parkways have a green space buffer between the roadway and adjacent development. Parkways preserve and enhance the natural landscape as much as possible.

1.3.6 Freeways

Freeways are divided arterial highways designed with full control of access and grade separation at all intersections. Freeways provide movement of high volumes of traffic at relatively high speeds. This system carries most of the trips entering and leaving the urban area, as well as most of the through movement by-passing the central city.

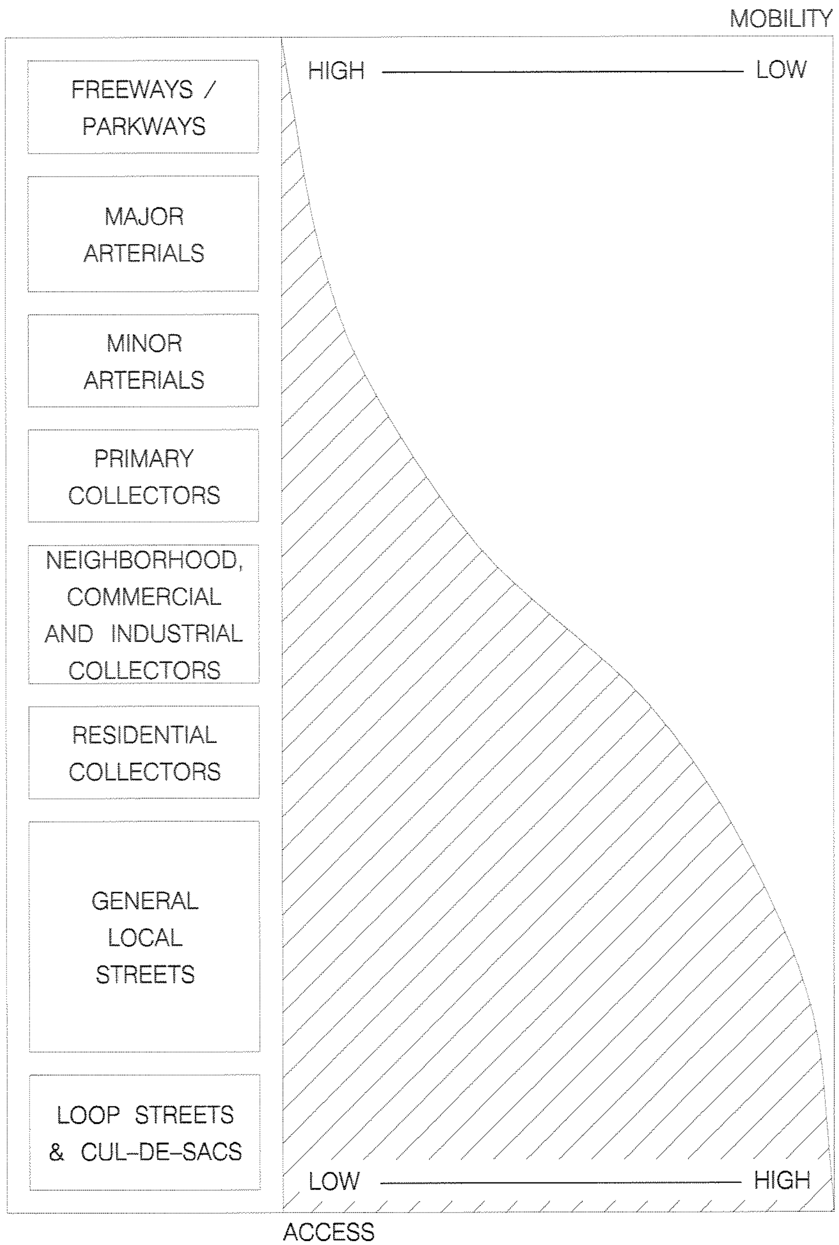


LEGEND

FREEWAYS /PARKWAYS
ARTERIAL STREETS
COLLECTOR STREETS
LOCAL STREETS
CUL–DE–SACS
SCHOOL

FIGURE 1–1

STREET NETWORK



SOURCE: ADAPTED FROM AASHTO – GEOMETRIC DESIGN OF HIGHWAYS AND STREETS, 1984.

FIGURE 1–2

RELATIONSHIP OF STREET CLASSIFICATIONS WITH ACCESS AND MOBILITY

1.4 Roadway Design Standards

Table 1-1 describes design standards for each roadway classification. Typical cross-sections for each classification are shown in Figures 1-3 through 1-14. Any deviations from these standards must be approved in writing by the City Engineer.

Table 1-1

Roadway Design Standards

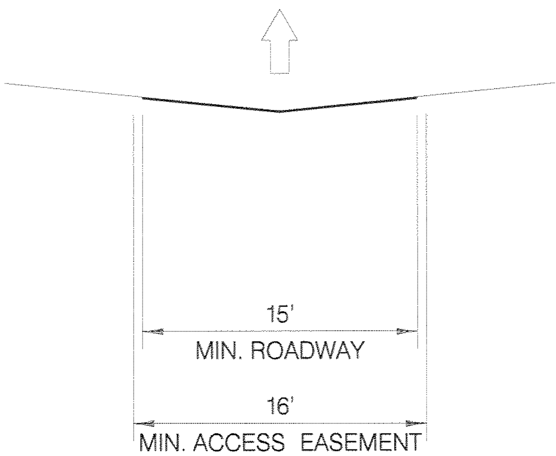
Design Elements	Alley	Residential Street	Residential Collector	Neighborhood Collector	Commercial/ Multifamily Collector	Industrial Collector	Minor Arterial	Major Arterial	Parkway	Freeway
Expected ADT (vpd)	-	500	500-3,000	500-3,000	2,000-10,000	> 3,500	3,500-12,000	9,000-20,000	18,000-30,000	18,000-30,000
Minimum Right-of-Way (feet)	16	53	62	54	80	70	82	100	140	150
Minimum Paved Width (feet)	15	30	38	30	48	44	58	70	2 @ 41	2 @ 46
Number of Lanes	1-2	2	2	2	2-4	4	4	2-4	6	6
Lane Width (feet)	15-20	10-11[a]	10-11[a]	10-11[a]	11-12	11 to 12	12	12	12	12
Design Speed	-	20-30	30-35	30-35	30-40	30-40	40-45	40-50	50-70	50-70
Curb Basis (feet)	-	10	10.5	10.5	14.5	11.5	10.5	13.5	14.5	14.5
Tangent Length between reverse curves (feet)	-	50	100-150	100-150	100-150	100-150	150-200	150-200	200	200
Spacing of Cross-Street (feet)	-	<300	300-500	300-500	500	500	1000	1000	1300	1300
Driveways permitted	-	Yes	Yes	Yes	Restricted	Restricted	Restricted	Restricted	No	No
Driveway Spacing (feet) [b]	-	1 Driveway/ Property	50-75	50-75	75-100	75-100	150-200	150-200	-	-
Parking	-	Yes	Yes	Yes	Restricted	Restricted	Restricted	No	No	No
Landscaping	-	Both sides	Both sides	Both sides	Both sides	Both sides	Both sides	Both sides	Both sides	Both sides
Sidewalks	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Grades % (max) [c]	2	8	8	8	8	8	8	8	6	6
Min. Median Widths (feet)	-	-	4	4	4	4	6	6	23	23
Expected percent of Heavy Vehicles (%)	-	1.7	1.4-8.3	1.4-8.3	2.0-9.8	2.0-9.8	12.1-34.0	34.0-50.0	Full access	Full access

a. With additional parking lanes of 7 - 8 feet on both sides.

b. Varies with the design speed of the roadway and is different for City and TxDOT roadways. Refer to Chapter 5: Driveway Design and Access Management.

c. For construction of steeper grades, detailed traffic and environmental studies are required.

TYPICAL CROSS–SECTION

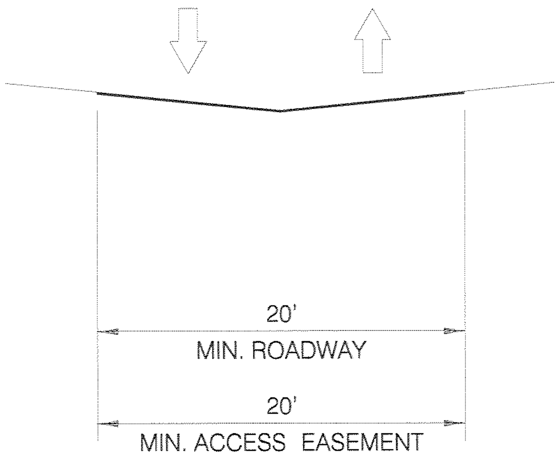


MINIMUM ROADWAY WIDTH: 15'
MINIMUM ACCESS EASEMENT WIDTH: 16'

FIGURE 1–3

DESIGN CRITERIA FOR ONE–WAY ALLEYS

TYPICAL CROSS-SECTION



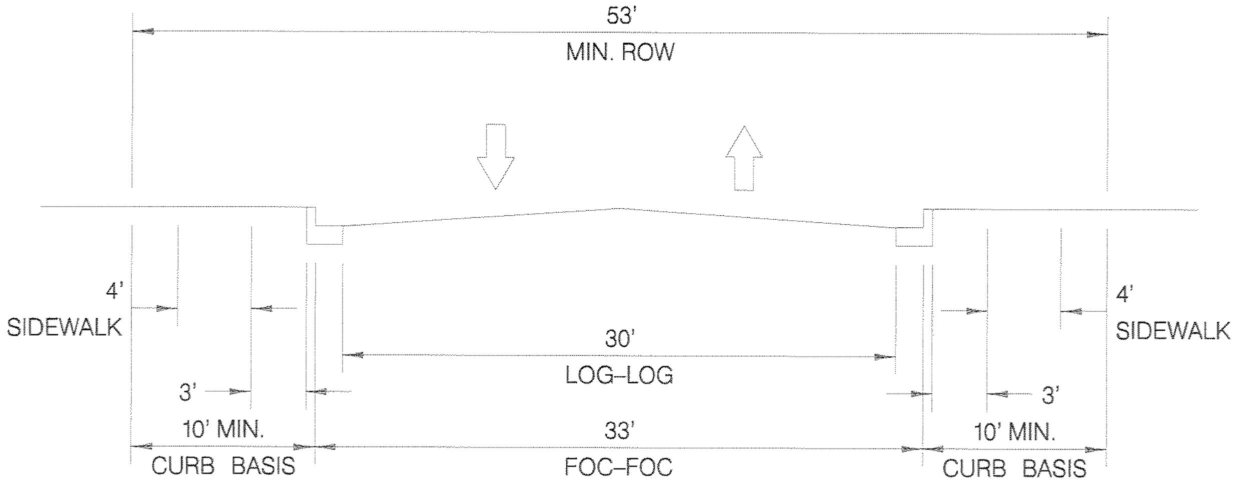
MINIMUM ROADWAY WIDTH: 20'

MINIMUM ACCESS EASEMENT WIDTH: 20'

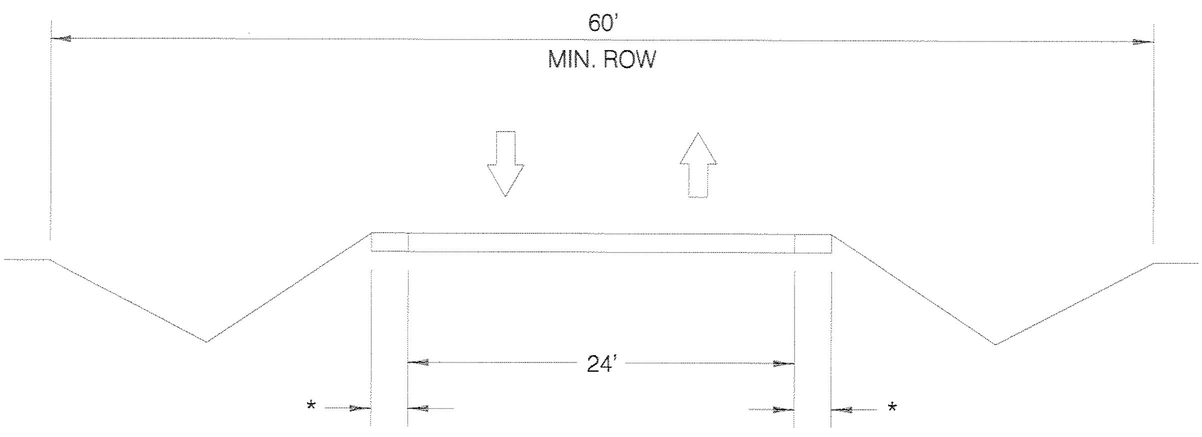
FIGURE 1-4

DESIGN CRITERIA FOR TWO-WAY ALLEYS

TYPICAL CROSS-SECTION



ALTERNATE CROSS-SECTION WITHOUT STANDARD CURB AND GUTTER



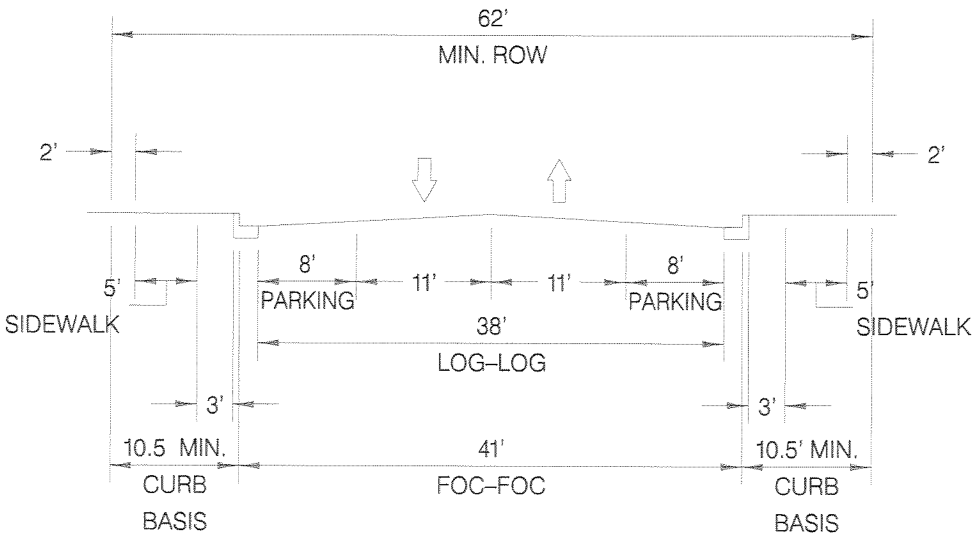
* 1.5' MIN. RIBBON CURB OR 2' SHOULDER

TYPICAL ADT RANGE: 500
DESIGN SPEED: 20, 25, 30 mph
GENERAL LENGTH: less than 1500'
TANGENT LENGTH BETWEEN HORIZONTAL CURVES: 50'
MINIMUM CURB BASIS: 10'
TYPICAL SPACING BETWEEN INTERSECTIONS: <300'

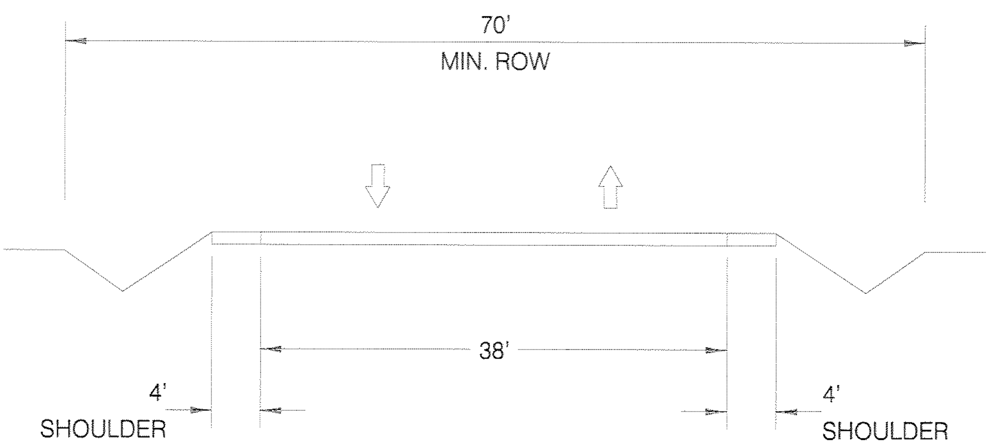
FIGURE 1-5

DESIGN CRITERIA FOR RESIDENTIAL STREETS

TYPICAL CROSS–SECTION



ALTERNATE CROSS–SECTION WITHOUT STANDARD CURB AND GUTTER

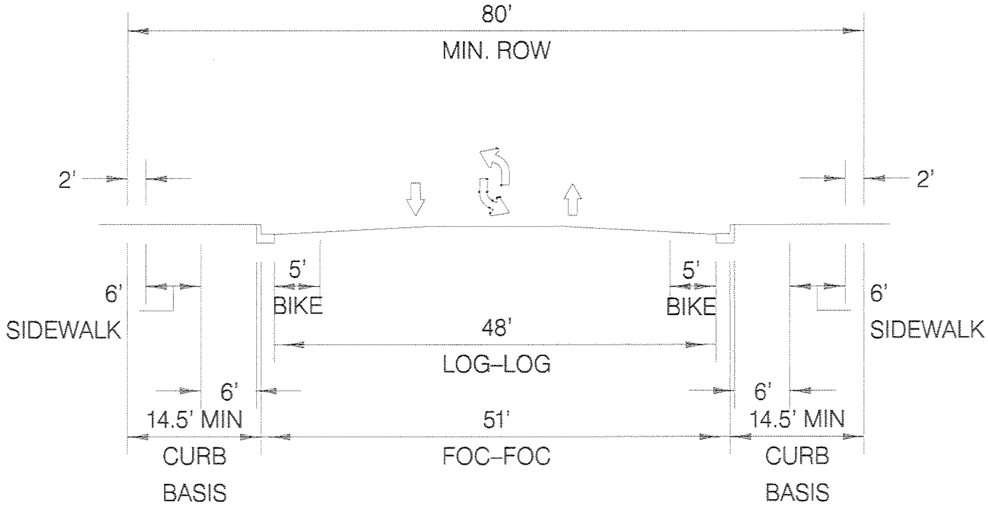


TYPICAL ADT RANGE: 500 to 3000
DESIGN SPEED: 30, 35 mph
GENERAL LENGTH: less than 1 mile
TANGENT LENGTH BETWEEN HORIZONTAL CURVES: 100' – 150'
MINIMUM CURB BASIS: 10.5'
TYPICAL SPACING BETWEEN INTERSECTIONS: 300' – 500'

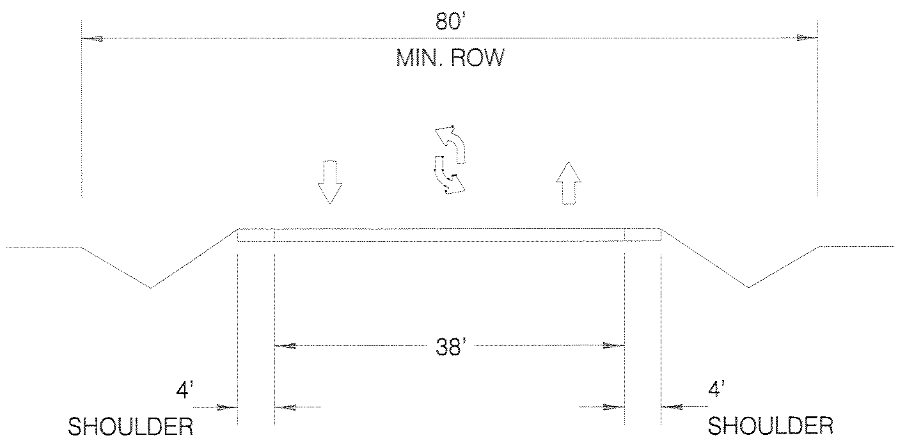
FIGURE 1–6

DESIGN CRITERIA FOR RESIDENTIAL COLLECTOR STREETS

TYPICAL CROSS-SECTION



ALTERNATE CROSS-SECTION WITHOUT STANDARD CURB AND GUTTER



TYPICAL ADT RANGE: 2000 – 10000

DESIGN SPEED: 30, 35, 40 mph

GENERAL LENGTH: less than 2 miles

TANGENT LENGTH BETWEEN HORIZONTAL CURVES: 100' – 150'

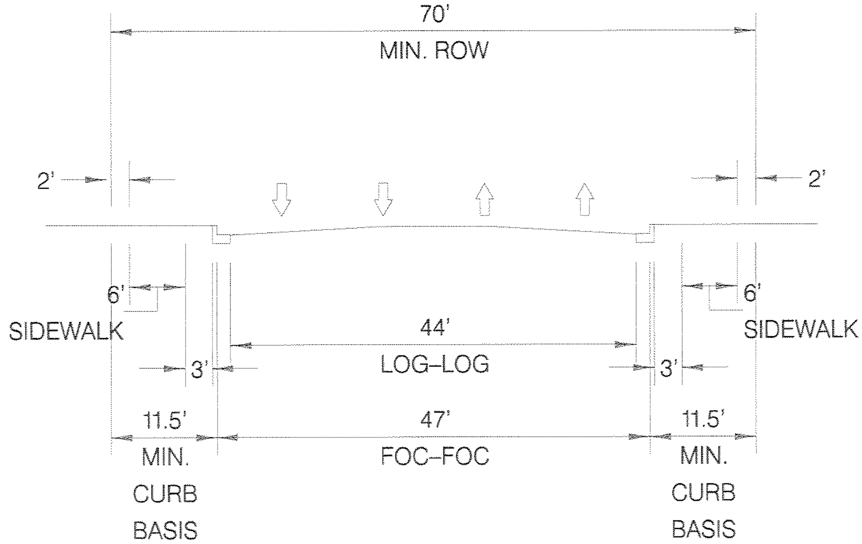
MINIMUM CURB BASIS: 14.5'

TYPICAL SPACING BETWEEN INTERSECTIONS: 500'

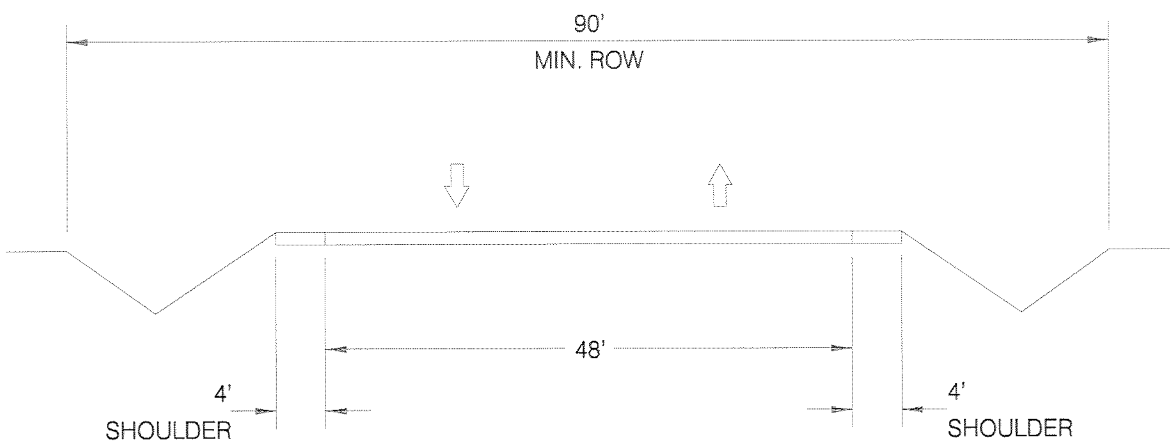
FIGURE 1–8

DESIGN CRITERIA FOR COMMERCIAL / MULTIFAMILY COLLECTOR STREETS

TYPICAL CROSS-SECTION



ALTERNATE CROSS-SECTION WITHOUT STANDARD CURB AND GUTTER



TYPICAL ADT RANGE: > 3500

DESIGN SPEED: 30, 35, 40 mph

GENERAL LENGTH: less than 2 miles

TANGENT LENGTH BETWEEN HORIZONTAL CURVES: 100' – 150'

MINIMUM CURB BASIS: 11.5'

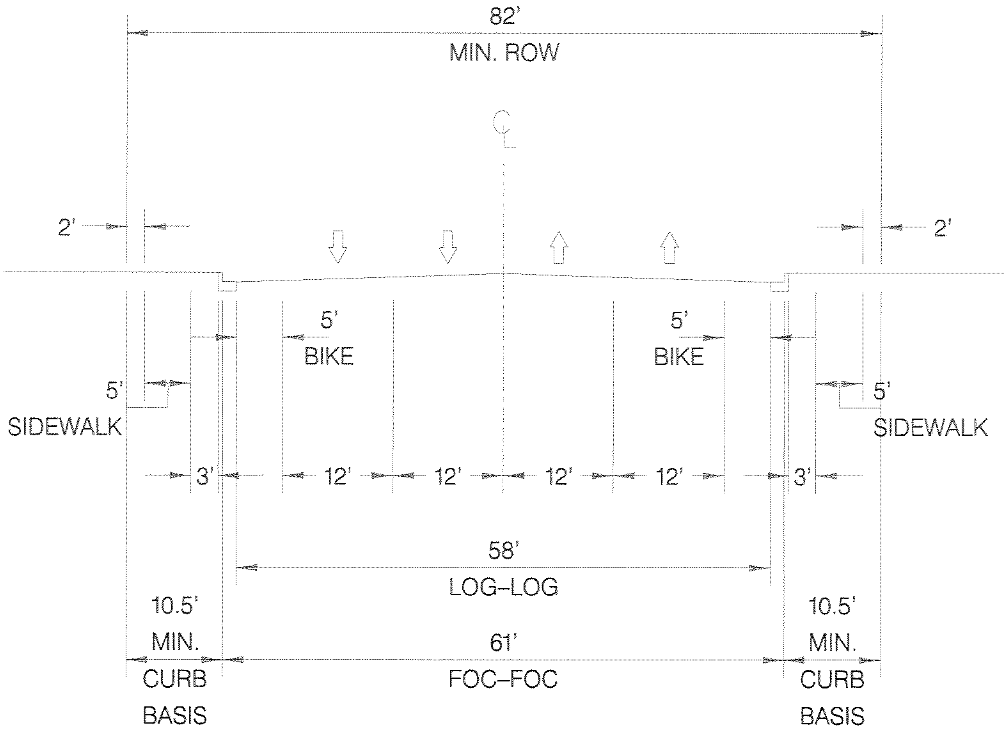
TYPICAL SPACING BETWEEN INTERSECTIONS: 500'

NOTE: CRITERIA FOR INDUSTRIAL COLLECTORS MAY BE APPLIED WITH APPROVAL BY THE CITY ENGINEER.

FIGURE 1-9

DESIGN CRITERIA FOR INDUSTRIAL COLLECTOR STREETS

TYPICAL CROSS-SECTION

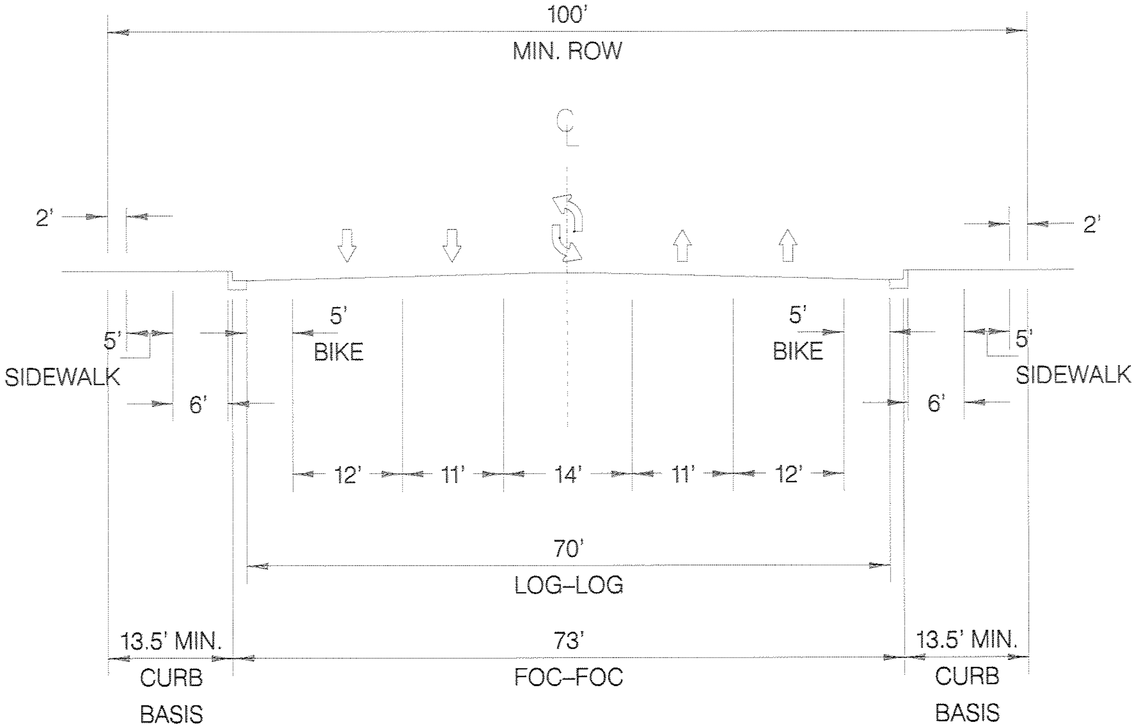


TYPICAL ADT RANGE: 3500 – 12000
DESIGN SPEED: 40, 45 mph
TANGENT LENGTH BETWEEN HORIZONTAL CURVES: 150' – 200'
MINIMUM CURB BASIS: 10.5'
TYPICAL SPACING BETWEEN INTERSECTIONS: 1000'

FIGURE 1–10

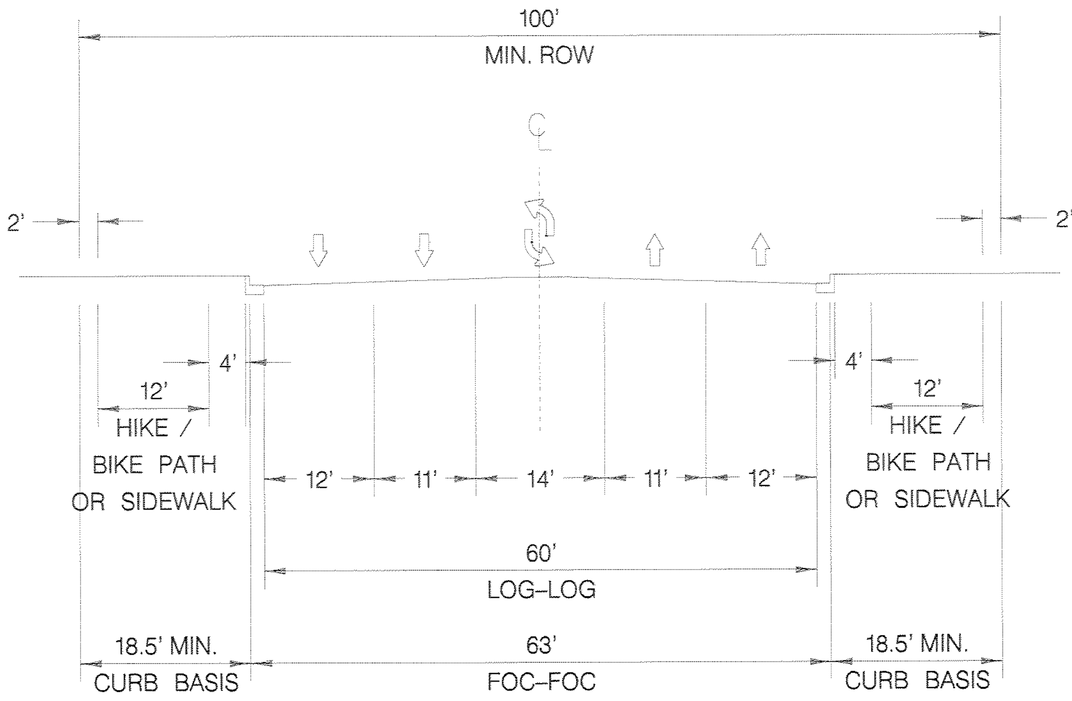
DESIGN CRITERIA FOR FOUR–LANE UNDIVIDED MINOR ARTERIAL STREET

TYPICAL CROSS–SECTION



TYPICAL ADT RANGE: 9000 – 20000 DESIGN SPEED: 40, 45, 50 mph TANGENT LENGTH BETWEEN HORIZONTAL CURVES: 150' – 200' MINIMUM CURB BASIS: 13.5' TYPICAL SPACING BETWEEN INTERSECTIONS: 1000'	FIGURE 1–11 DESIGN CRITERIA FOR FOUR–LANE DIVIDED MAJOR ARTERIAL STREET

TYPICAL CROSS-SECTION



TYPICAL ADT RANGE: 9000 – 20000

DESIGN SPEED: 40, 45, 50 mph

TANGENT LENGTH BETWEEN HORIZONTAL CURVES: 150' – 200'

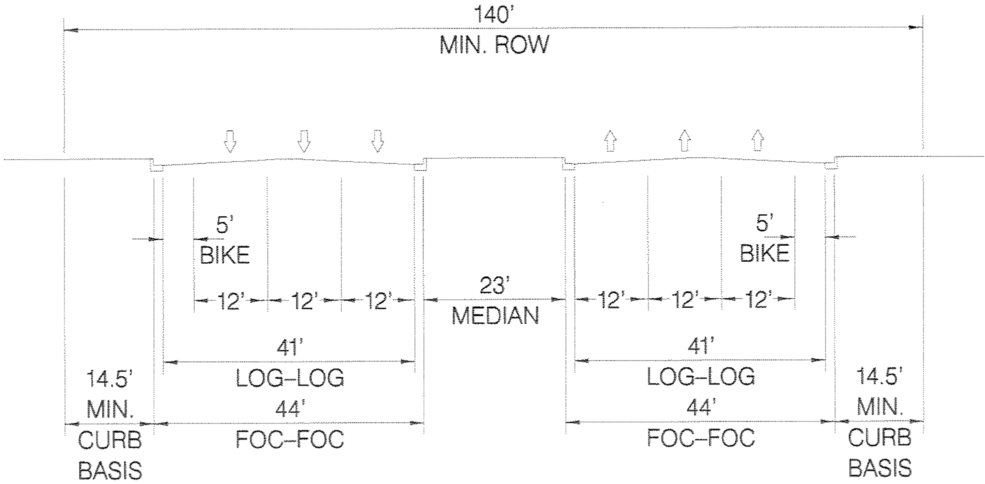
MINIMUM CURB BASIS: 18.5'

TYPICAL SPACING BETWEEN INTERSECTIONS: 1000'

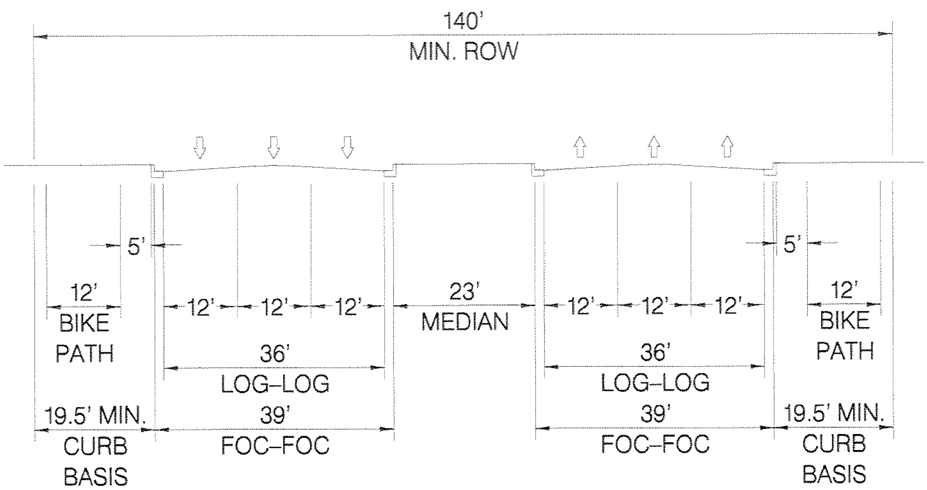
FIGURE 1–12

ALTERNATE DESIGN CRITERIA FOR FOUR–LANE DIVIDED MAJOR ARTERIAL STREET

TYPICAL CROSS-SECTION



ALTERNATE CROSS-SECTION



TYPICAL ADT RANGE: 18000 - 30000

DESIGN SPEED: 50, 55, 60, 65, 70 mph

TANGENT LENGTH BETWEEN HORIZONTAL CURVES: 200'

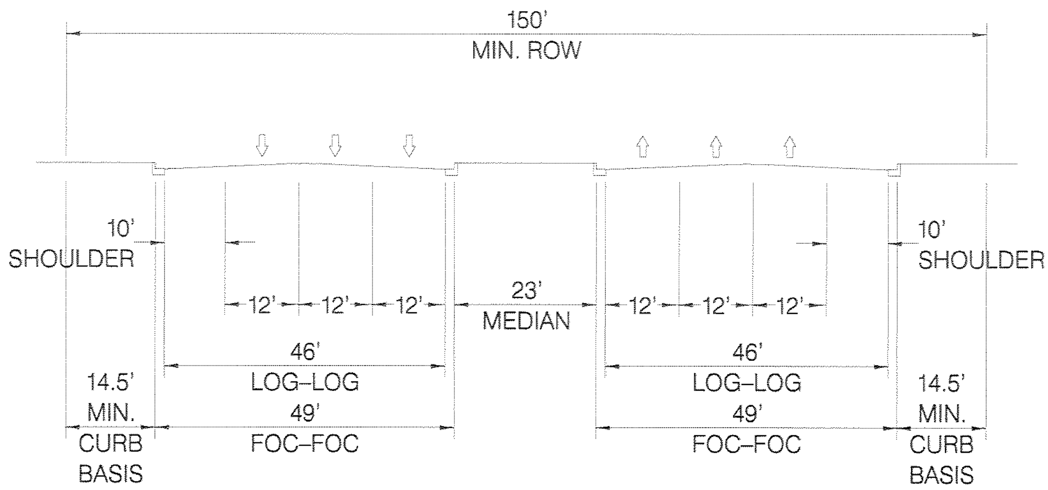
MINIMUM CURB BASIS: 14.5'

TYPICAL SPACING BETWEEN INTERSECTIONS: 1300'

FIGURE 1-13

DESIGN CRITERIA FOR SIX-LANE PARKWAY

TYPICAL CROSS-SECTION



TYPICAL ADT RANGE: 18000 – 30000

DESIGN SPEED: 50, 55, 60, 65, 70 mph

TANGENT LENGTH BETWEEN HORIZONTAL CURVES: 200'

MINIMUM CURB BASIS: 14.5'

TYPICAL SPACING BETWEEN INTERSECTIONS: 1300'

FIGURE 1-14

DESIGN CRITERIA FOR SIX-LANE FREEWAY

1.5 Geometric Design Standards

The geometric design standards described below were based on material from the American Association of State Highways and Transportation Officials' (AASHTO), A Policy on Geometric Design of Highways and Streets, 2001 (AASHTO's Green Book). The latest version of this manual shall be consulted and the most restrictive standard used for design purposes.

1.5.1 Stopping Sight Distance

The available stopping sight distance on a roadway shall be sufficient for a vehicle traveling at the design speed to stop before reaching a stationary object ahead. Stopping sight distance is a sum of two distances: brake reaction time and braking distance. The brake reaction time is the time it takes for the driver to see an object ahead and apply the brakes. A value of 2.5 seconds is the default; however, this time may need to be increased depending on road conditions. The braking distance is the distance traveled by the vehicle after the brakes are applied and before the vehicle can come to a complete stop. A vehicle deceleration rate of 11.2 ft/s^2 is the default used; however, this rate may need to be reduced depending on the road conditions. For calculating the stopping sight distance, the height of the driver's eye is estimated to be at 3.5 ft and the height of the object is estimated at 2 ft. Table 1-2 provides the minimum required stopping sight distance for different design speeds. Although greater lengths of visibility are preferred, these minimum stopping sight distances should be maintained at every point along the roadway. These stopping sight distances are also applicable for crest and sag vertical curves.

Table 1-2
Minimum Stopping Sight Distance

Design Speed (mph)	Minimum Stopping Sight Distance (feet)
15	80
20	115
25	155
30	200
35	250
40	305
45	360
50	425
55	495
60	570
65	645
70	730

Source: AASHTO 's Green Book

Note: These distances were computed for grades < 3% and for wet pavement conditions.

1.5.1.1 Sight Obstructions

On a tangent roadway, obstructions that limit the driver's view include the roadway surface at some point along a vertical crest or a physical feature outside the travel way. Therefore, all subdivision and site plans submitted to the City should be reviewed for sight distance obstructions in both the vertical and horizontal plane. The most recent version of the AASHTO 's Green Book shall be used for measuring and recording sight distances on plans.

1.5.1.2 Intersection sight Distance

Refer to Chapter 2 Section 2.4.7 for details on intersection sight triangles and sight distance requirements.

1.5.2 Horizontal Alignment

As vehicles move in a circular path, they undergo a centripetal acceleration that pushes towards the center of the curve. This centripetal acceleration is governed by the vehicle's weight related to the superelevation of the roadway and the side friction that develops between the vehicle's tires and the pavement surface. Limiting values for superelevation rate (e) and side friction demand (f) have been established for the design of horizontal curves and are discussed below.

1.5.2.1 Superelevation

The factors that limit the rate of superelevation are climatic conditions, terrain conditions, constructability, type of area, adjacent land uses, and frequency of slow moving vehicles. Table 1-3 provides superelevation rates that should be used for design.

Table 1-3
Superelevation rates and Applicable Conditions

Superelevation Rate (%)	Conditions
1.5 to 2	▪ Minimum needed for drainage. ▪ Low seed urban streets with sever constraints.
4 to 6	▪ Urban design with little to no constraints.
8	▪ Maximum allowable without approval from City Engineer.

1.5.2.2 Side Friction Factor

Horizontal curves should be designed at a side friction demand which will provide a safe and comfortable maneuver over the horizontal curve for a majority of drivers. The upper limit on side friction factor is also known as the point of impending skid, it is that point when tires begin to skid. Side friction factor shall be determined based on the type of facility being designed using the most recent version of the AASHTO's Green Book's guidelines.

1.5.2.3 Minimum Horizontal Radii

Minimum horizontal radius is a directly related to roadway design speed, maximum rate of superelevation, and maximum side friction selected for the design. The minimum horizontal radius (R_{min}) is calculated using the following formula:

$$R_{min} = \frac{V^2}{15*(0.01\ e_{max} + f_{max})}$$

Where: V *vehicle speed in mph*

e_{max} *maximum rate of superelevation for the design speed*

f_{max} *maximum side friction selected for the design*

Source: AASHTO's Green Book

Table 1-4 provides examples of minimum radii lengths for limiting values of e (superelevation) and f (side friction) for low speed urban streets.

Table 1-4

Minimum Radii Limiting Values of e and f

Design Speed (V) (mph)	e_{max}	f_{max}	R_{min} (feet)
30	0.06	0.221	270
35	0.06	0.197	413
40	0.06	0.178	597

1.5.2.4 Transition Design Curves

Transition design curves shall meet the design requirements set forth in the most recent version of AASHTO's Green Book.

1.5.3 Vertical Alignment

The topography of the land effects vertical alignment. Terrain classification is important in order to establish the design characteristic for vertical alignment of the roadway. Terrain could be level, rolling, or mountainous. This classification should be determined prior to design of the roadway.

1.5.3.1 Maximum Grades:

Maximum grades for each functional classification of roadway are shown in Table 1-1. Grades higher than eight percent shall require a detailed traffic and environmental study to be performed by the developer's engineer and approved by the City Engineer.

1.5.3.2 Minimum Grades

In general, a minimum grade of 0.5 percent shall be maintained. However, a grade of 0.3 percent may be used on high-type pavement which is properly sloped and supported on a firm subgrade.

1.5.3.3 Vertical Curves

The design should result in comfortable and safe maneuverability and adequate drainage. The minimum length of a vertical curve shall be based on sight distance criteria, although longer lengths are preferred and may be needed if located at a driver's decision point. Crest and Sag vertical curves shall be designed in accordance with the latest version of AASHTO's Green Book.

1.5.3.4 Reverse Curves

Reverse curves shall be separated by a minimum tangent of 100 feet. Reverse curves on high-speed facilities should include an intervening tangent section of sufficient length to provide adequate superelevation transition between curves.

1.5.4 Horizontal Clearance

Roadside obstructions should be located at or near the right-of-way line and beyond the sidewalks. On urban streets with no shoulders, a clearance of 1.5 feet or more beyond the face of the curb should be provided.

1.5.5 Vertical Clearance

Vertical clearance at underpasses for residential and collector streets should be should be at least 14 feet, over the entire roadway width, with an additional allowance for resurfacing. The vertical clearance for arterials and freeways should be at least 16 feet.

1.5.6 Cross-Slopes

Pavement cross-slopes should be adequate to provide proper drainage. Cross-slopes should be 1.5 to 3.0 percent where there are flush shoulders adjacent to travel ways or where there are outer curbs.

1.5.7 Curb Basis

Curb basis is the distance between the face of curb and the right-of-way line. This distance varies with the functional classification of the roadway. Curb basis for each functional classification of roadways are shown in Table 1-1.

1.6 Street and Subdivision Layouts

Adequate streets shall be provided by the subdivider and the arrangement, character, extent, width, grade and location of each shall conform to the comprehensive plan and shall be considered in their relation to existing and planned streets, topographical conditions, public safety and convenience and in their appropriate relationship to the proposed uses of land to be served by the streets. The street layout shall be devised for the most advantageous development of the entire neighborhood and to maintain connectivity to adjacent development.

1.6.1 STREET LIGHTING

Lighting should be provided to improve the safety of highways or streets and the ease and comfort of operation. Properly designed street lighting will improve comfort and visibility at night. This should improve and encourage vehicular and pedestrian movement. Streetlights shall be installed by the subdivider at all intersections, at the end of cul-de-sacs and shall have no greater distance than 600 feet between them within or abutting the subdivision.

1.6.2 UTILITIES ASSIGNMENTS

All public utilities shall be contained within the public street right-of-way or abutting utility easement not less than 15 feet in width. It is the City's policy to locate the water, wastewater, and storm sewer utilities under the paved street section. Electric, natural gas, telephone, and cable television utilities shall be located between the right-of-way line and back of curb (outside the paved street section), where permissible.

The utility assignments described in Table 1-5 And Figure 1-15 shall be complied with for all new City streets.

Table 1-5
Utility Assignments

Utility	Location
Water	4 ½ Feet Inside Face of Curb
Wastewater	5 Feet Offset Street Centerline, Low Side of Street
Storm Sewer	5 Feet Offset Street Centerline, High Side of Street
Electric	2 Feet Inside Right-of-Way Line
Natural Gas	7 Feet Inside Right-of-Way Line
Telephone	2 Feet Inside Right-of-Way Line
Cable Television	2 Feet Inside Right-of-Way Line

Note: Telephone, Cable Television and Electric (if underground) may be installed in a common trench.

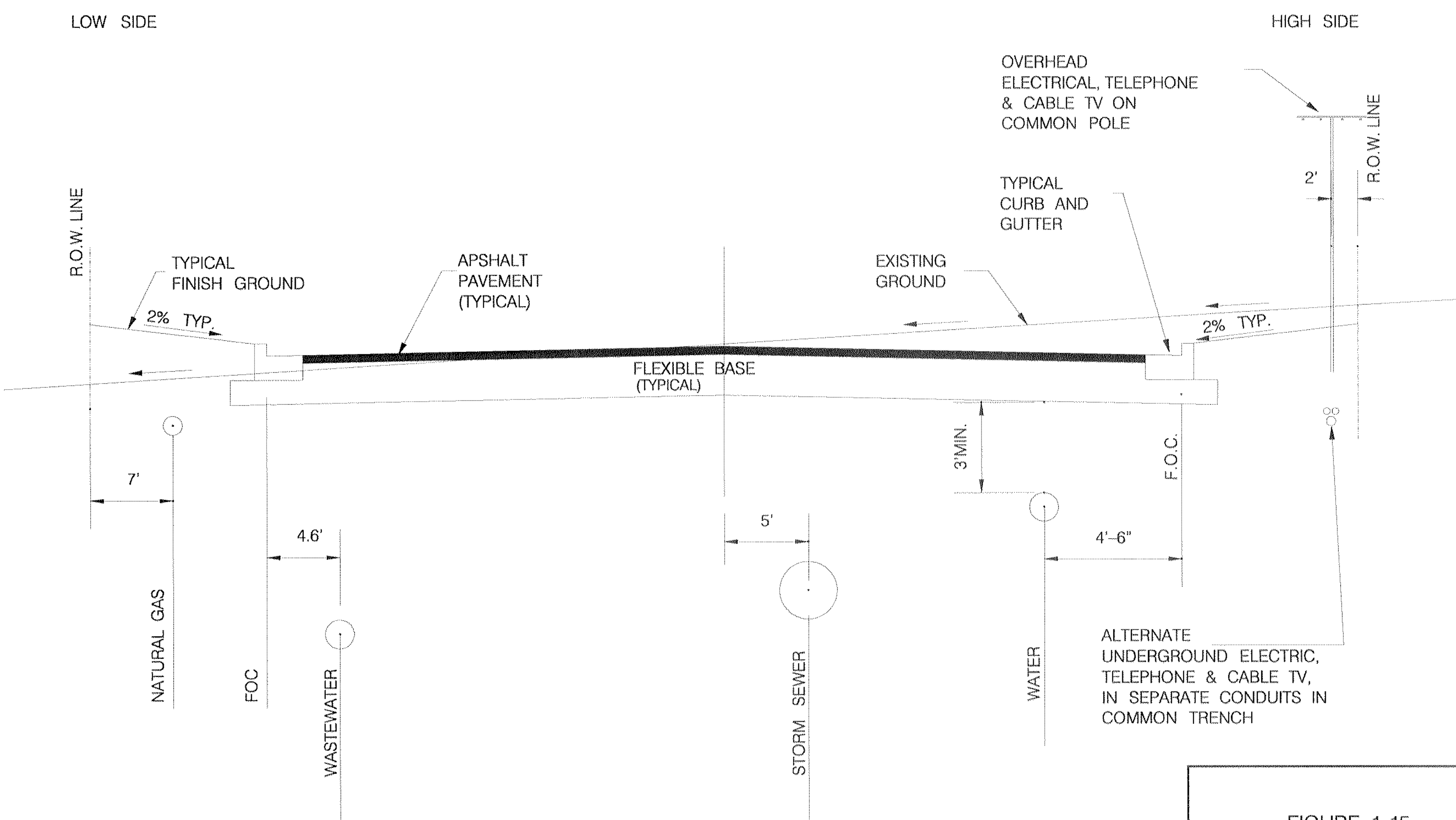


FIGURE 1-15

TYPICAL PROPOSED UTILITY ASSIGNMENTS IN NEW CITY STREETS

1.6.3 Cul-De-Sac

A cul-de-sac is the circular turnaround at the end of a short, dead-end street. Figures 1-16 through 1-18 depict design criteria for residential, commercial, and industrial cul-de-sacs, respectively.

1.6.3.1 When the most desirable residential plan requires a dead-end street, the street shall terminate in a cul-de-sac.

1.6.3.2 Cul-de-sacs shall not be more than 500 feet in length unless approved by the City Engineer for specific reasons concerning topography or engineering design.

1.6.3.3 The minimum right-of-way radius for residential cul-de-sacs shall be 60 feet with a minimum driving surface radius of 40 feet.

1.6.3.4 The minimum right-of-way radius for non-residential cul-de-sacs shall be 100 feet with a minimum driving surface radius of 90 feet.

1.6.3.5 Construction of cul-de-sacs shall include proper signage at the entrance to inform drivers that the street is not a through street.

1.6.4 Temporary Turnarounds

If a street is proposed to extend into a future section or another subdivision, temporary easements shall be dedicated for the construction of a temporary turnaround meeting the standards set forth in Table 1-6. The temporary turnaround shall be removed upon construction of the roadway.

Table 1-6
Minimum Turnaround Requirements

Design Elements	Residential	Non-Residential
Right-of-way (feet)	60	100
Pavement Radius (feet)	50	90
Center Island Radius (feet) (If desired)	20	N/A

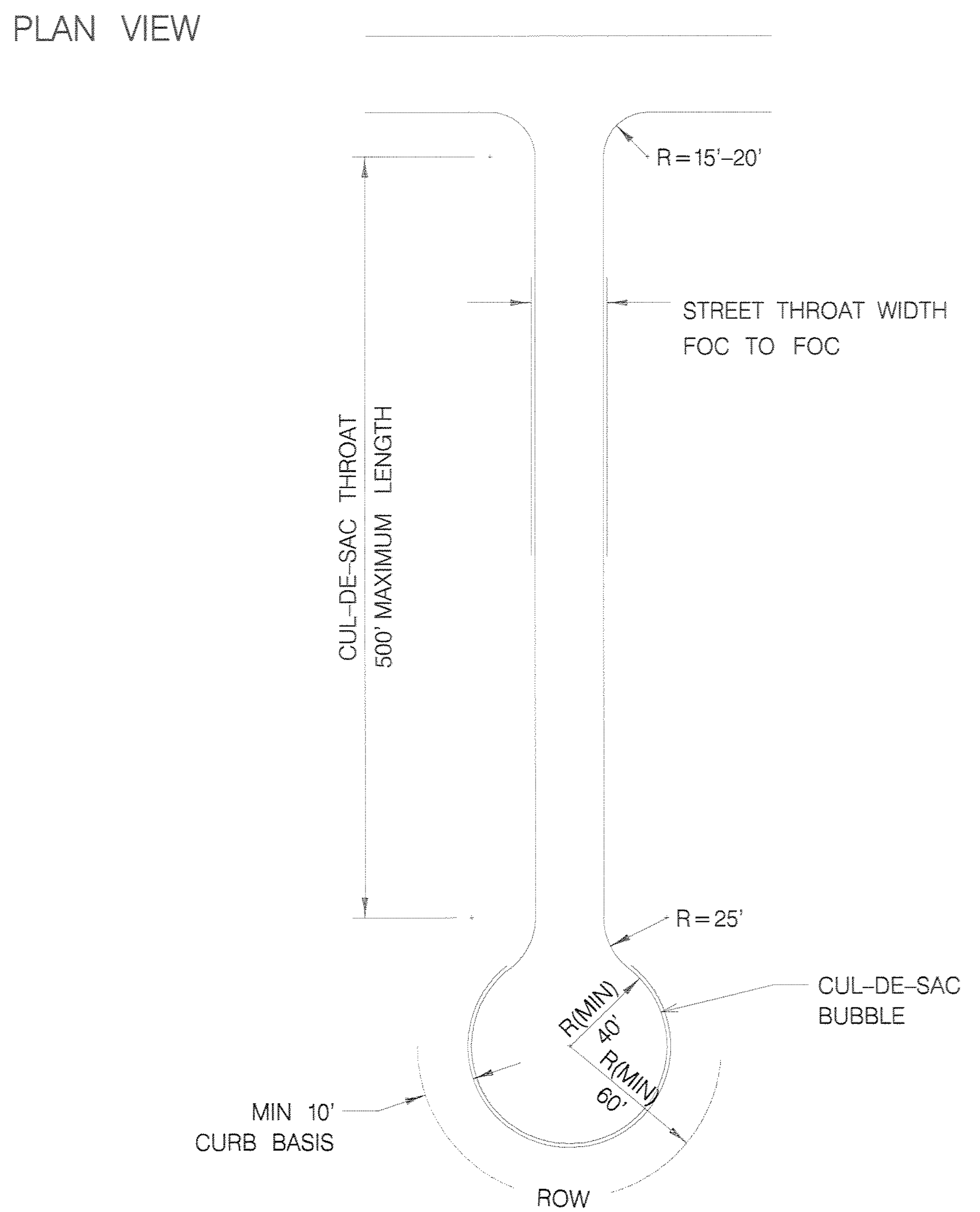


FIGURE 1–16

DESIGN CRITERIA
FOR
RESIDENTIAL
CUL–DE–SACS

PLAN VIEW

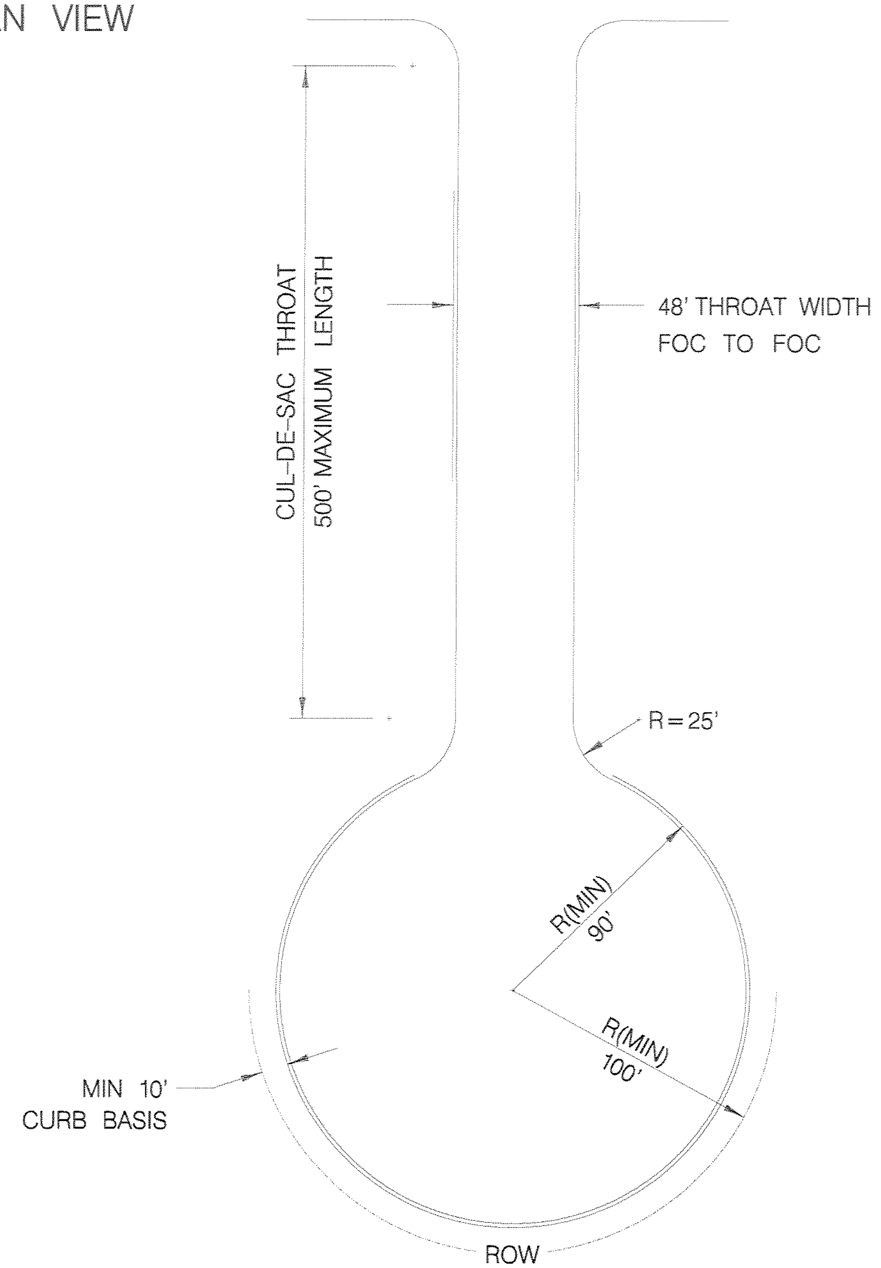


FIGURE 1-17

DESIGN CRITERIA
FOR
COMMERCIAL
CUL-DE-SACS

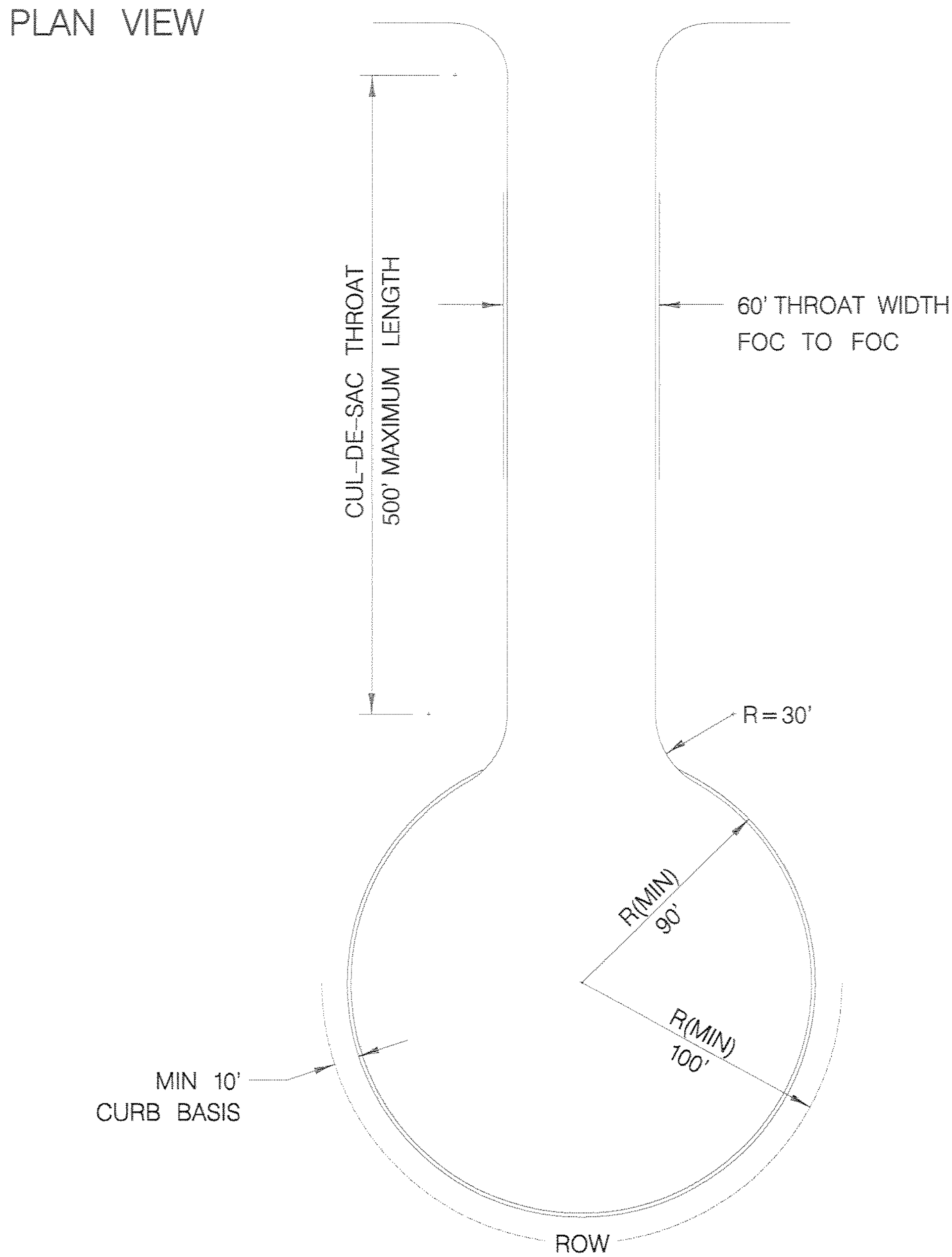


FIGURE 1–18

DESIGN CRITERIA
FOR
INDUSTRIAL
CUL-DE-SACS

1.6.5 Single Outlet Streets

Issues regarding single outlet streets are partially alleviated by providing mid-block turnarounds, increasing pavement widths, and utilizing divided roadways as shown in Table 1-7. The following single outlet street criteria are applicable to new developments. When future extensions of the street network are anticipated, which will add outlets, a temporary restriction may be placed on the amount of development allowed, until an additional outlet is available.

Table 1-7
Single Outlet Streets

Average Daily Traffic Volume	Street Width (FOC-FOC)
< 300	30′
300 – 1000	36′
1000 – 2500	40′ or 44′
2500 – 4000	2 @ 24′ w/ 16′ min median width
> 4000	TIA Required

Source: City of Austin's Transportation Criteria Manual

** If the distance from the beginning of the single outlet street to the end of the cul-de-sac throat exceeds 2000′, then the single outlet street must be designed with 2 @ 24′ w/ 16′ min median width.*

1.6.6 Half Street or Half Alleys

No half streets or half alleys are permitted along the boundaries of proposed subdivisions.

1.6.7 Block Lengths

Residential blocks in subdivisions shall not exceed twelve hundred (1,200) feet in length nor be less than six hundred (600) feet unless such blocks are parallel to and adjacent to a thoroughfare, in which case such blocks shall not exceed sixteen hundred (1,600) feet in length. Commercial and industrial block lengths may be up to two thousand (2,000) feet in length: provided, that the requirements of traffic circulation and utility service are met. Block lengths may be varied according to the requirements of circulation, utility service, topography and provisions of the City Master Plan.

1.6.8 Block Widths

Block widths in subdivisions shall be such to allow for two (2) tiers of lots back to back, except where abutting a thoroughfare to which access to the lots is prohibited, or where prevented by topographical conditions or size of the property.

1.6.9 Marginal Access Streets

Where a subdivision has frontage on an arterial street, the Planning and Zoning Commission may require marginal access streets to be provided on both sides or on the subdivision side of the arterial street, if the arterial street borders the subdivision, unless the adjacent lots back up to, side up to or front with extra depth and access off an alley and provide some other means of restricting individual access.

1.6.10 Relation to Adjoining Street System

Where necessary to the neighborhood pattern, existing streets in adjoining areas shall be continued and shall be at least as wide as the existing streets and in alignment with the existing streets.

1.6.11 Projection of Streets

Where adjoining areas are not subdivided, the arrangement of streets in the subdivision shall make provision for the proper projection of streets into the unsubdivided area.

1.6.12 Reverse Strips

There will be no reverse strips of land, except those conveyed or dedicated to the government having jurisdiction.

1.6.13 Connectivity

Connectivity, an interconnected roadway network, promotes public health, safety and welfare of the city. It is necessary to ensure that all streets function in an interdependent manner to provide adequate access for emergency and service vehicles as well as improve walkability. All streets in a proposed subdivision shall be continuous and connect to existing, platted, or planned streets, unless approved by the City Engineer

1.6.14 Street Names

1.6.14.1 New streets in a subdivision shall be named in a way that will provide continuity of street names and prevent conflict or confusion with existing street names in the City, in the City's extraterritorial jurisdiction or in a neighboring jurisdiction. A proposed new street name is in conflict with the subsection where:

- It duplicates or sounds phonetically similar to the name of a street already in use within the city or the city's extraterritorial jurisdiction or designated as a future extension in the current thoroughfare plan;
- It differs from an existing street name in the city or the city's extraterritorial jurisdiction by the addition of an auxiliary designation including "avenue," "way," "boulevard," "etc.; or
- The street to be named is an extension of or is in substantial alignment with an existing street in the city, the city's extraterritorial jurisdiction or a neighboring jurisdiction and the proposed street name is different from the existing street name.

1.6.14.2 Renaming of existing streets shall be initiated by either a citizen petition, or by the City. This request for renaming an existing street shall be approved by the Planning and Zoning Commission and by the City Council.

1.6.15 Street Signs

Street signs shall be installed by the subdivider at all intersections within or abutting the subdivision. These signs shall be of a type approved by the city and will be installed according to city standards.

1.6.16 Curbs and gutters.

Curbs and gutters or extended curbs shall be installed in the subdivision on both sides of all interior streets and on the subdivision side of all streets forming part of the boundary of the subdivision, according to city construction standards.

1.6.17 Conformity to Design Requirements

No plat will be approved by the Planning and Zoning Commission or the Planning Director, no construction plans will be approved by the City Engineer, and no completed improvements will be approved or accepted by the City Engineering, unless they conform to the transportation design requirements and City standards.

1.6.18 Conformity to The Comprehensive Plan

The subdivision shall conform to the adopted City Master Plan.

1.7 Environmental Considerations

All new or rehabilitated City streets shall be designed to minimize the limits of disturbance (construction) and the removal of existing trees. All existing trees to remain within the limits of disturbance shall be adequately protected by fencing or other approved means. It is recommended that the selected alignments of all new City streets be based on an on-the-ground survey of all existing trees, 12" and larger in diameter. Revegetation of the disturbed pervious areas shall be accomplished as soon as possible after paving and/or sidewalk construction is completed in order to minimize any erosion potential.

For any City street construction over the Edwards Aquifer Recharge Zone or Contributing Zone, conformance to the Texas Commission on Environmental Quality (TCEQ) regulations shall be required. Where applicable, water quality control improvements are to be provided with the street construction, and, shall be totally contained within the public street right-of-way or abutting drainage easement (on private property). The design of any City street-related water quality control improvements shall be made by a Licensed Professional Engineer required in the State of Texas.

1.8 Pavement Design

The pavement designs for all City streets shall be in accordance with the American Association of State Highway and Transportation Officials (AASHTO) Pavement Design Guide, 2002 or latest approved edition. A geotechnical investigation and pavement design recommendation report, prepared by a Licensed Professional Engineer registered in the State of Texas, shall be required for all new or rehabilitated construction of City streets.

The pavement structure shall be designed for a 20-year service life. Average daily traffic counts shall be based on the future land use projections of the specific area being developed (or considered). Trip generation estimates will be based on Institute of Transportation Engineers (ITE) criteria, and, will include an average 2.5% growth rate per year for San Marcos and its ETJ. The ADT counts shall include the percentage of trucks, which will be used in determining the equivalent 18-Kip single axle loads.

The City of Austin has developed a "Computerized Pavement Design Procedure." This procedure modifies the AASHTO Pavement Design Guide concepts for the local Central Texas conditions. It is recommended that this procedure be formally adopted by the City of San Marcos.

The proposed pavement design section shall incorporate the following minimum requirements, as shown in Table 1-8.

Table 1-8
Pavement Design Requirements

Component	Minimum Requirement
Hot Mix Asphaltic Concrete	1 ½"
Pavement Surface Course	
Reinforced Concrete Pavement	6"
Crushed Limestone Flexible Base	8"
Lime Stabilized Subgrade	8"
Cement Stabilized Subgrade	6"
Compacted and Scarified Subgrade	6"

1.9 DRAINAGE ISSUES FOR ROADWAYS

The drainage designs for all new or rehabilitated City streets should comply with the objectives and goals of the City's Drainage Master Plan – one of them being "to limit the impact of storm flows on roadway inundation." In order to help meet this goal, San Marcos has adopted the City of Austin Drainage Criteria Manual. This manual does provide adequate technical design criteria to limit flooding of roadways. Some of the design criteria includes the following:

- Drainage improvements, being curbs and gutters, inlets and storm sewers, shall be designed to intercept and convey all runoff from the 25-year frequency storm. Additionally, the 100-year frequency storm flows shall be conveyed within specifically defined rights-of-way or drainage easements.

- For bridges and culverts in residential and non-residential streets, the 100-year frequency storm runoff shall not result in a depth at the roadway greater than 12" and 6", respectively, or to the top of the upstream curb elevation, whichever is lower.
- Curb inlets and storm sewers shall be located and designed to minimize interference to traffic by reducing the depth and spread of water in the street section. The street crown will not be allowed to be lowered to obtain additional hydraulic capacity.
- For all new or rehabilitated City streets without curbing, all flows are to be totally contained within a parallel roadside channel or ditch. Additionally, all driveway and street crossing culverts shall have 6:1 end treatments in accordance with TxDOT standard details.
- Stormwater discharges from a public drainage system shall not exceed a velocity of six (6) feet per second without velocity dissipation and erosion protection measures.
- All drainage computations relating to new or rehabilitated construction of City streets shall be prepared by a Licensed Professional Engineer registered in the State of Texas.

2.1 General

An intersection is as an area where two or more roadways join or cross. Intersections form an area of conflict for vehicles and should be designed to facilitate safety, efficiency, ease and convenience for pedestrians, bicycles and motor vehicles.

2.2 Types of Intersections

Intersections can have three-legs (T intersections), four-legs, or be roundabouts. Intersections with more than four legs are discouraged. Figures 2-1 through 2-3 detail a three-leg intersection, four-leg intersection and roundabout.

2.3 Intersection of Curbed Streets with Uncurbed Streets

Curbed to uncurbed street intersections shall be designed with appropriate concern for the interfacing of the differing drainage systems. The following criteria shall be met:

- Where a curbed street intersects a continuing uncurbed street, standard curb and gutter shall terminate at the property line or as necessary to allow drainage from the curbed street to enter the uncurbed street ditch without erosion to shoulder areas. Concrete or mortared rock riprap may be required to protect the shoulder area.
- Where an uncurbed street intersects a continuing curbed street, the curb line shall be cut and removed and a standard urban curb return designed into the uncurbed street with the curb face at the ditch centerline of the uncurbed street. A concrete riprap transition shall be constructed to convey drainage out of or into the uncurbed ditch line. The concrete riprap transition may be eliminated for discharge into the uncurbed street if transition grades are less than two percent or if an inlet is located within 100 feet of the intersection.
- Pavement shall be placed on a particular radius. Care will be taken in installation to match existing pavement. The curbed street crown shall be full crown (unless cross spilling) to at least 50 feet from the curb end to assure that flow enters the ditch.
- For a curbed street discharging into an uncurbed street, surface drainage that has been carried by the curb and gutter from a point more than 200 feet distance from the intersection with the uncurbed street shall be removed by the use of inlets draining to a drainage pipe required at the intersection so as not to interrupt the flow of drainage in the ditch of the uncurbed street.
- Item 2.3.3 may be deleted if the surface drainage from the curbed street can be directed from the ends of the curb and gutter to the ditch of the uncurbed street without surcharge of the curb and gutter, exceeding the City of Austin's Drainage Criteria Manual, criteria for reduction of carrying capacity and provided adequate erosion control can be maintained.

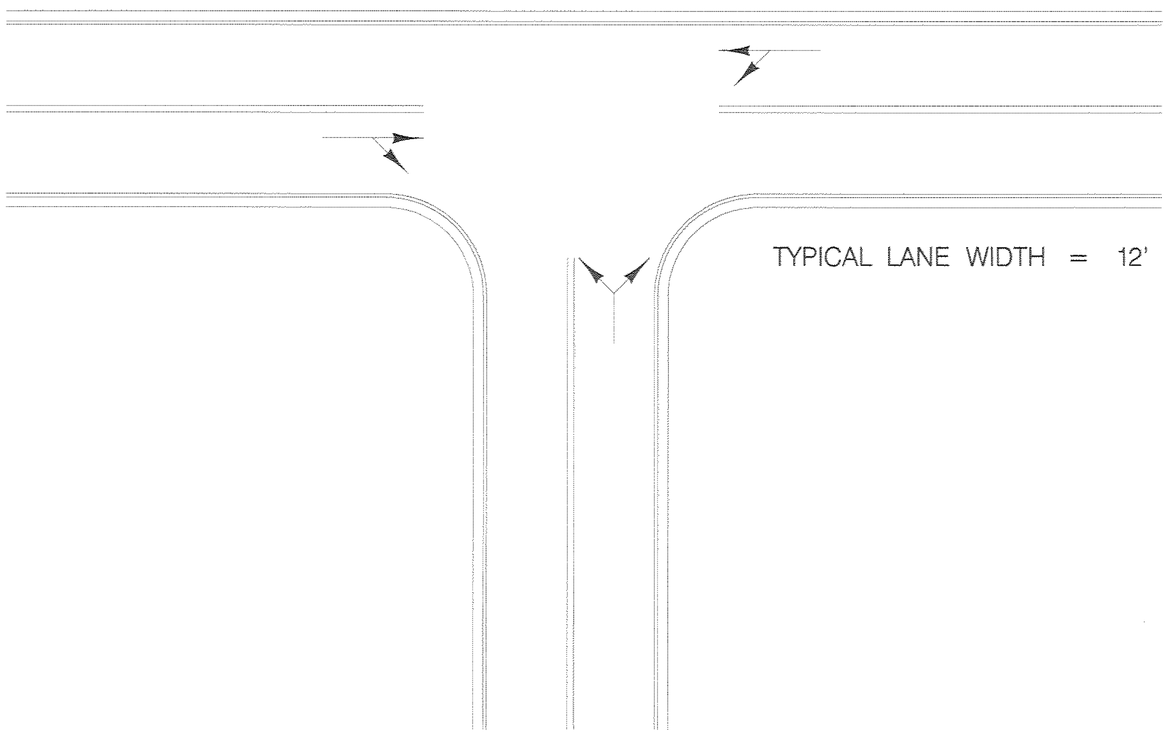


FIGURE 2–1

TYPICAL
THREE–LEG
INTERSECTION

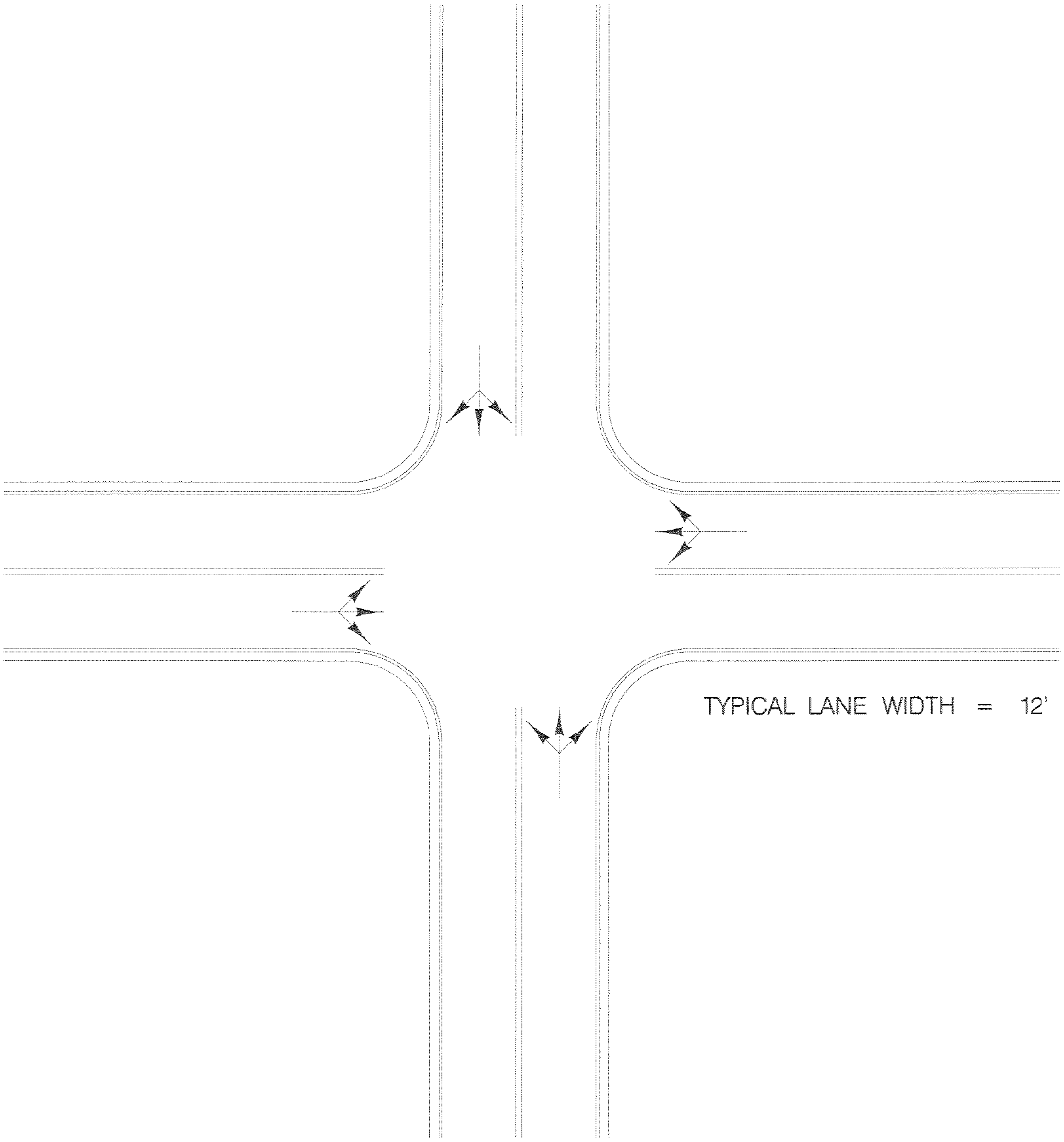


FIGURE 2–2

TYPICAL FOUR–LEG INTERSECTION

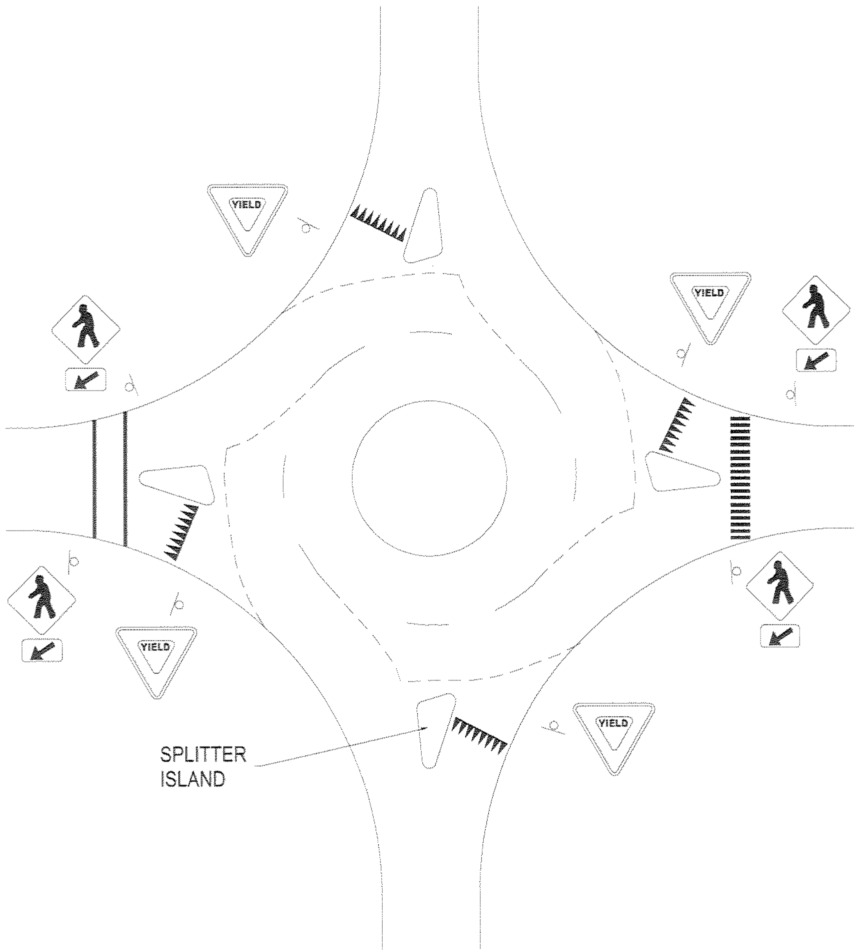


FIGURE 2-3

TYPICAL
ROUNDABOUTS
WITH TWO LANES

2.4 Intersection Design Characteristics

The following sections describe recommended design characteristics within the vicinity of an intersection.

2.4.1 Vertical Alignment

In general, intersections should be designed with a flat grade. However, this may not be feasible in difficult terrains. The grade and design speed for the major street should be maintained through the intersection approaches. In accordance with section 2.4.2, the minor street may not be designed with an approach grade of ± three percent, unless sight distances are in excess of the minimums listed in Table 1-2 for stopping on grade level, in which case the approach grade should not be greater than six percent. Deviations from these requirements shall require approval from the City Engineer.

2.4.2 Horizontal Alignment

The horizontal approach to an intersection should be tangent for a length of 50-100 feet, as shown in Table 1-1. The desirable angle of intersection is 90 degree. Intersections skewed at angles less than 80 degrees or more than 100 degrees should be avoided. Variations of more than ten degrees on minor streets and more than five degrees on major streets must be approved by the City Engineer. However, a tangent section of 50 feet shall be provided at the intersection approaches. Approach grades should be limited to ± three percent for at least the tangent section, unless sight distances are in excess of the minimums listed in Table 1-2 for stopping on a grade level, in which case the approach grade should not be greater than six percent. Deviations from these requirements shall require approval from the City Engineer. Intersections on sharp curves should be avoided since the superelevation and widening of pavements may complicate the intersection design and reduce sight distance.

2.4.3 Minimum curb radius

The minimum curb radius is based on the type of roadways intersecting each other. Table 2-1 describes minimum curb radii given the roadway types that are intersecting. These values have been developed assuming a passenger car vehicle without lane encroachment and a three-foot curb clearance. For intersection driveways which will carry large volumes of heavy vehicles, such as a truck delivery access, the curb radius should be designed to accommodate a WB-50 design vehicle.

Table 2-1

Minimum Curb Radius

Intersection Types	Min. curb radius (Feet)
Local Street – Local Street	15
Collector Street – Local Street	20
Collector Street – Collector Street	20
Arterial Street – Collector Street	25
Arterial Street – Arterial Street	30

2.4.4 MINIMUM CENTERLINE OFFSET OF ADJACENT INTERSECTION

2.4.4.1 To reduce hazardous practices, centerlines of opposed 'T' intersections shall be 125 feet apart for local-local intersections, 150 feet for local-collector intersections, and 200 feet for collector-collector intersections. In case of jogged collector-arterial or arterial-arterial intersections, greater offsets may be required, in order to allow for left-turn storage between intersections. If traffic signal warrants are met, then it is often safer to signalize the intersection.

2.4.4.2 The minimum separation between a 'T' intersection and a four-way intersection shall be 300 feet, except where the access to a higher use thoroughfares might be affected or where the topography would dictate a variation.

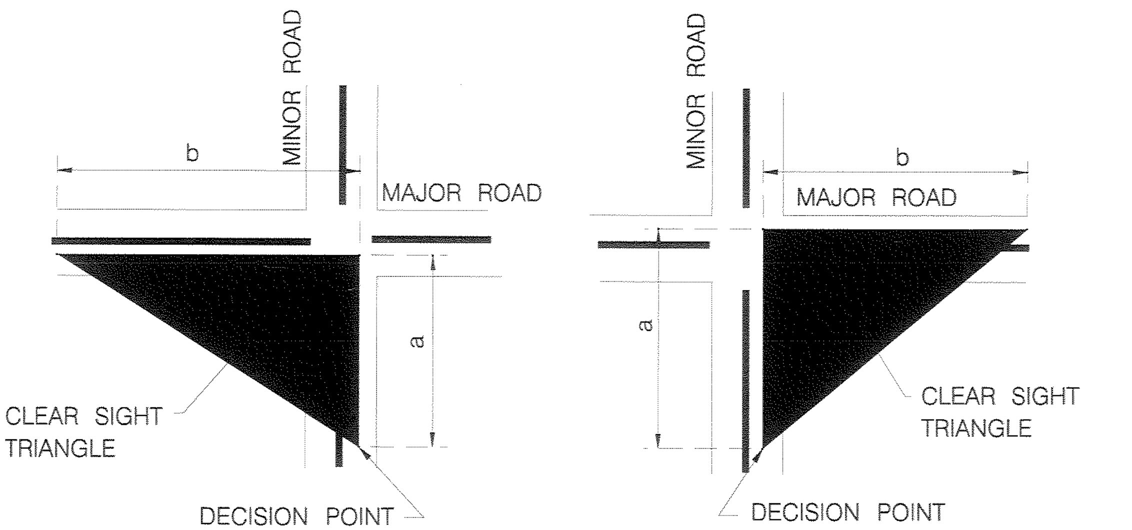
2.4.5 SIGHT DISTANCE

Intersections form an area of conflict for vehicles, pedestrians, and bicycles. If sufficient sight distance is provided, these conflicts can be greatly reduced. Provision of sufficient sight distance provides the driver sufficient time to adjust the speed, avoid an impending collision, and decide when to enter or cross the intersecting highway.

Certain areas at the corners of the intersections should be cleared of all obstructions that could limit the sight distance for drivers at the approach. These specified areas are known as sight triangles. There are two types of sight triangles: approach sight triangles and departure sight triangles.

2.4.5.1 Approach sight triangle, as shown in Figure 2-4, shall be provided to allow approaching drivers to see conflicting vehicles approaching the intersection. Sufficient lengths should be provided to allow for time to slow or stop before colliding.

2.4.5.2 Departure sight triangle, as shown in Figure 2-5, shall be provided to allow stopped drivers on the minor street approach sufficient time to turn left and right and enter to cross the intersection.



CLEAR SIGHT TRIANGLE FOR VIEWING TRAFFIC APPROACHING FROM THE LEFT

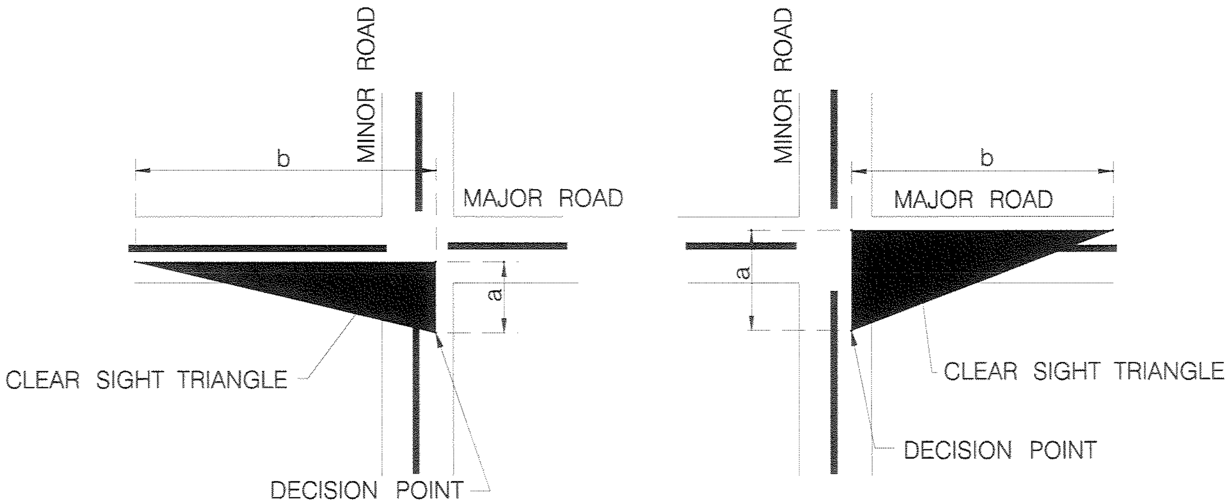
CLEAR SIGHT TRIANGLE FOR VIEWING TRAFFIC APPROACHING FROM THE RIGHT

SOURCE:
AASHTO – A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS

NOTE:
LENGTHS a AND b ARE DEPENDENT ON SPEED, INTERSECTION GEOMETRY, AND TRAFFIC CONTROL AT THE INTERSECTION. THESE DISTANCES MUST BE CALCULATED. SEE THE MOST RECENT VERSION OF AASHTO'S A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS FOR DETAILS.

FIGURE 2–4

APPROACH SIGHT TRIANGLE



CLEAR SIGHT TRIANGLE FOR VIEWING TRAFFIC APPROACHING FROM THE LEFT

CLEAR SIGHT TRIANGLE FOR VIEWING TRAFFIC APPROACHING FROM THE RIGHT

SOURCE:
AASHTO – A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS

NOTE:
LENGTHS a AND b ARE DEPENDENT ON SPEED, INTERSECTION GEOMETRY, AND TRAFFIC CONTROL AT THE INTERSECTION. THESE DISTANCES MUST BE CALCULATED. SEE THE MOST RECENT VERSION OF AASHTO'S A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS FOR DETAILS.

FIGURE 2–5

DEPARTURE SIGHT TRIANGLE

Intersection sight distance varies with different types of traffic control. These include intersections with no control, intersections with stop control on the minor road, intersections with yield control on the minor road, intersections with traffic signal control, intersections with all-way stop, and Left turn from major road.

Intersection sight distance is based on the intersection geometry, speed, and time gap. The most recent version of AASHTO's Green Book should be consulted to obtain appropriate factors and to calculate intersection sight distance.

2.5 Median Design

The following design criterion for medians were obtained from the Institute of Transportation Engineers report, Guidelines of Urban Major Street Design, 1983.

2.5.1 Function of Medians

A median is a part of a divided highway that separates traffic in opposite directions or in some cases lanes of traffic in the same direction. Medians or center left turn lanes (should be considered for all major urban streets.

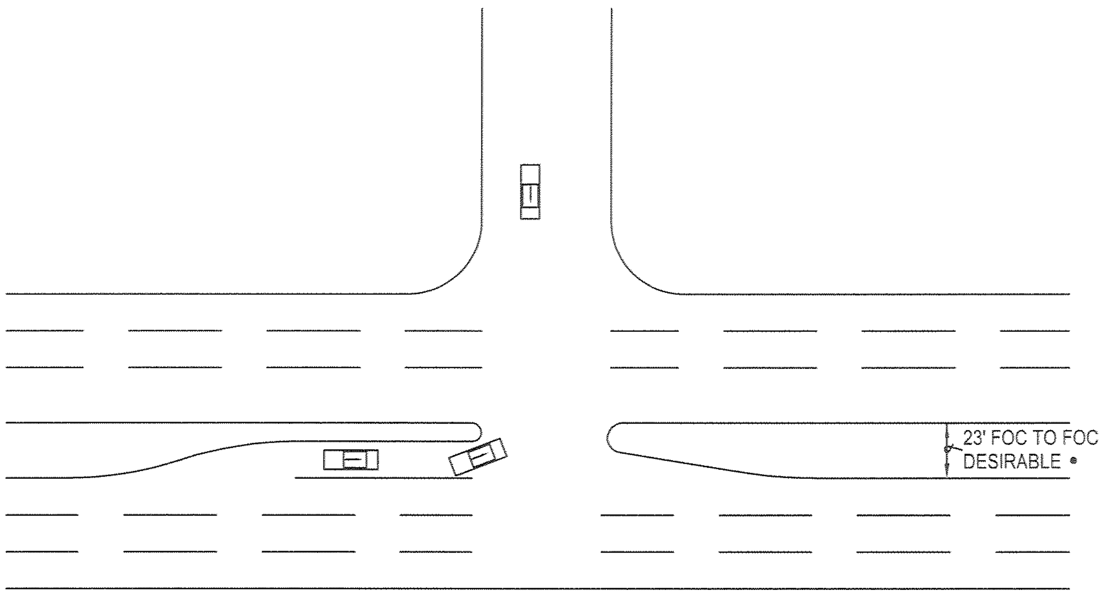
2.5.1.1 Medians can provide benefits such as space for traffic control devices, storage of left-turn, U-turn traffic, a recovery area for out-of-control vehicles, reduction of headlights glare, a refuge area for pedestrians and bicyclists, and allow for future expansion of the through roadway. Good median design can smooth traffic flow and reduce conflicts.

2.5.1.2 Wide medians can provide for drainage systems, lighting, utilities, and other roadway facilities.

2.5.1.3 Roadways, which require three lanes in each direction, resulting in a seven-lane section, can produce problems for pedestrians to cross. In such cases, curbed medians may be warranted.

2.5.2 Median Types

Medians can be depressed, raised, or flush with regard to their adjacent traveled way. Typically, sections wider than 16 feet are depressed for drainage purpose. Raised medians allow for access control, landscaping, and a positive visual barrier, which prevents cross-traffic movements. Flush medians are generally narrow and paved. Different types of median openings are shown in Figures 2-6 through 2-11.



● 16' FOC TO FOC APPROPRIATE FOR 4 LANE DIVIDED

FIGURE 2-6

TYPICAL MEDIAN APPLICATION FOR PROVIDING LEFT-TURN DECELERATION AND STORAGE INTO DRIVEWAY OR CROSS-STREET

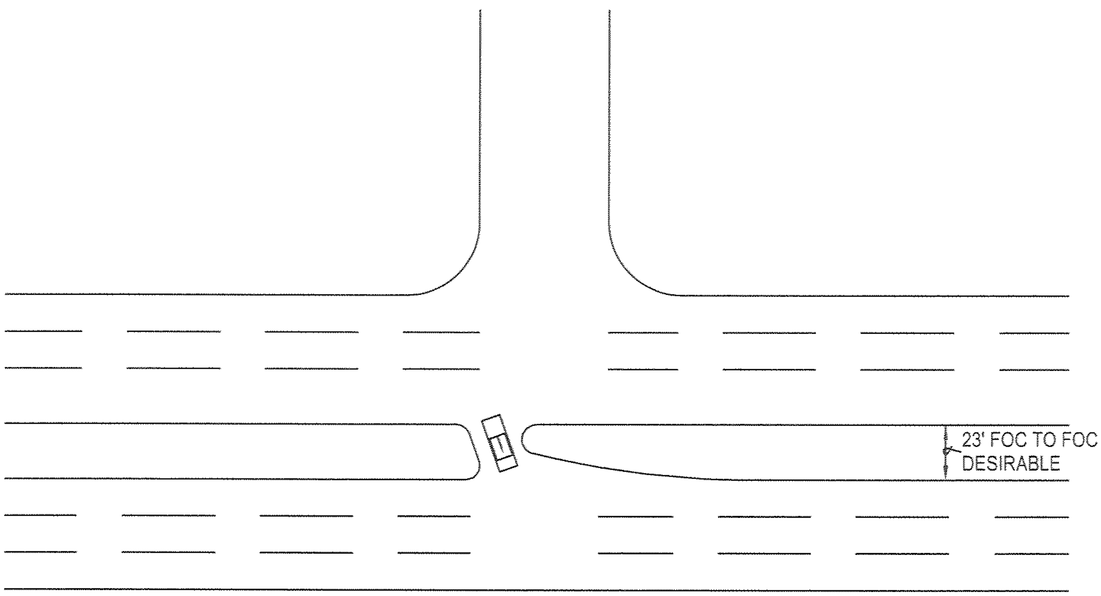
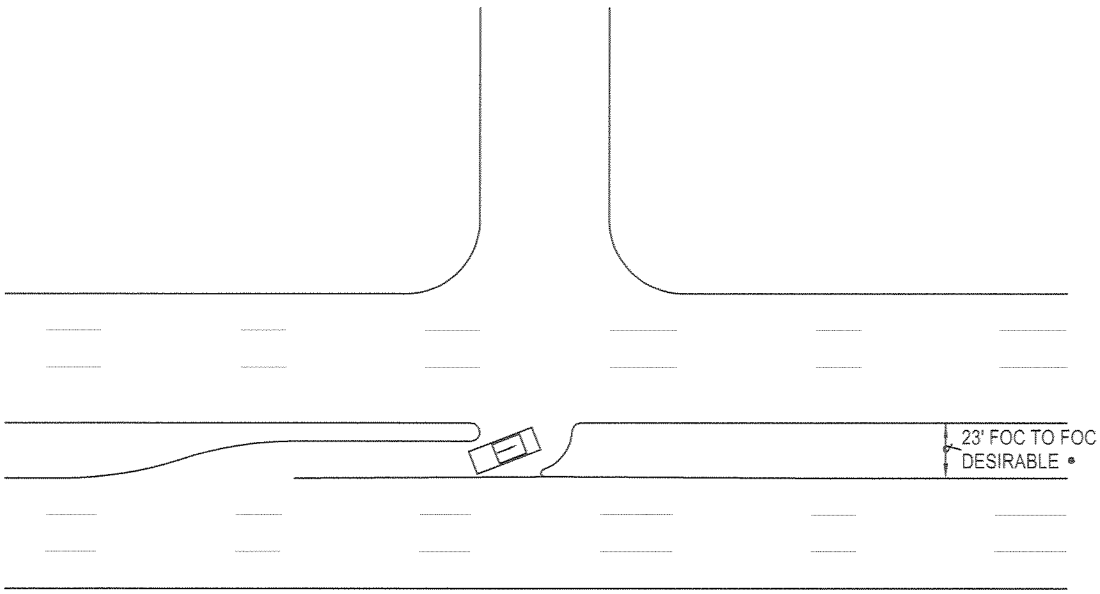


FIGURE 2-7

TYPICAL MEDIAN APPLICATION FOR PROVIDING CROSSING VEHICLE PROTECTION FROM A DRIVEWAY OR CROSS-STREET



● 16' FOC TO FOC APPROPRIATE ON 4 LANE DIVIDED

FIGURE 2-8

TYPICAL MEDIAN APPLICATION, LIMITATION OF MOVEMENT TO ENTERING LEFT-TURNS, ONE DIRECTION

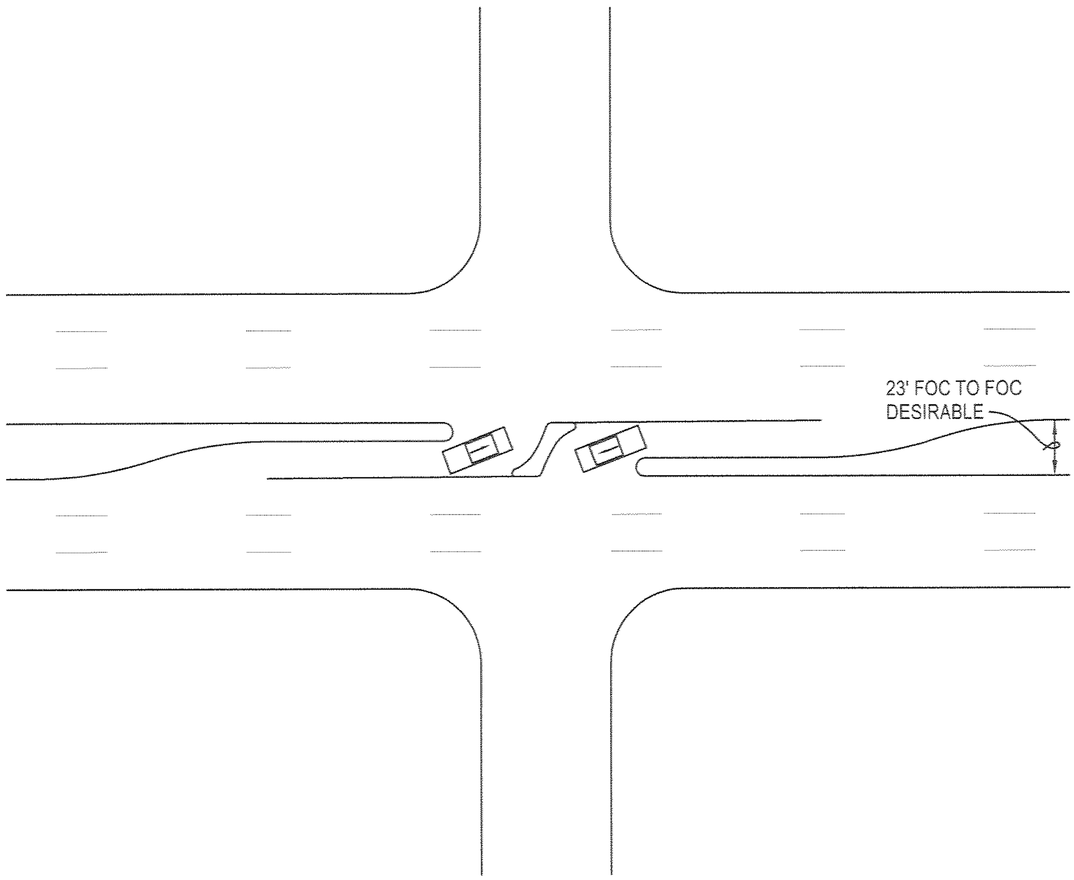


FIGURE 2-9

TYPICAL MEDIAN APPLICATION, LIMITATATION OF MOVEMENT TO ENTERING LEFT-TURNS, TWO DIRECTIONS

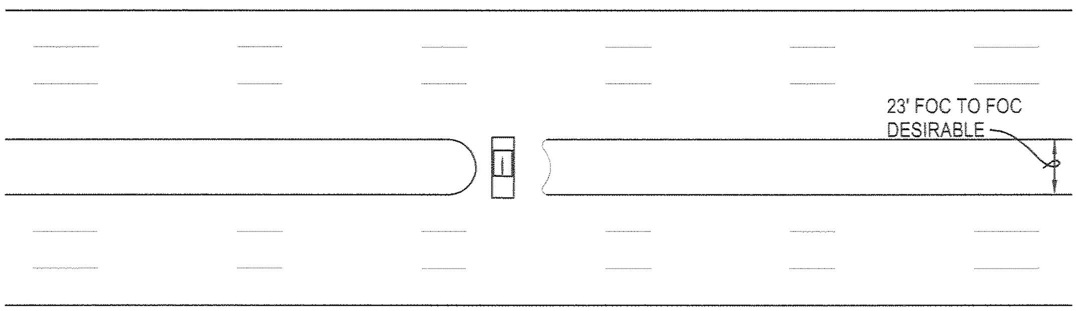


FIGURE 2-10

TYPICAL MEDIAN
APPLICATION, PROVIDING
"U" TURN MOVEMENTS

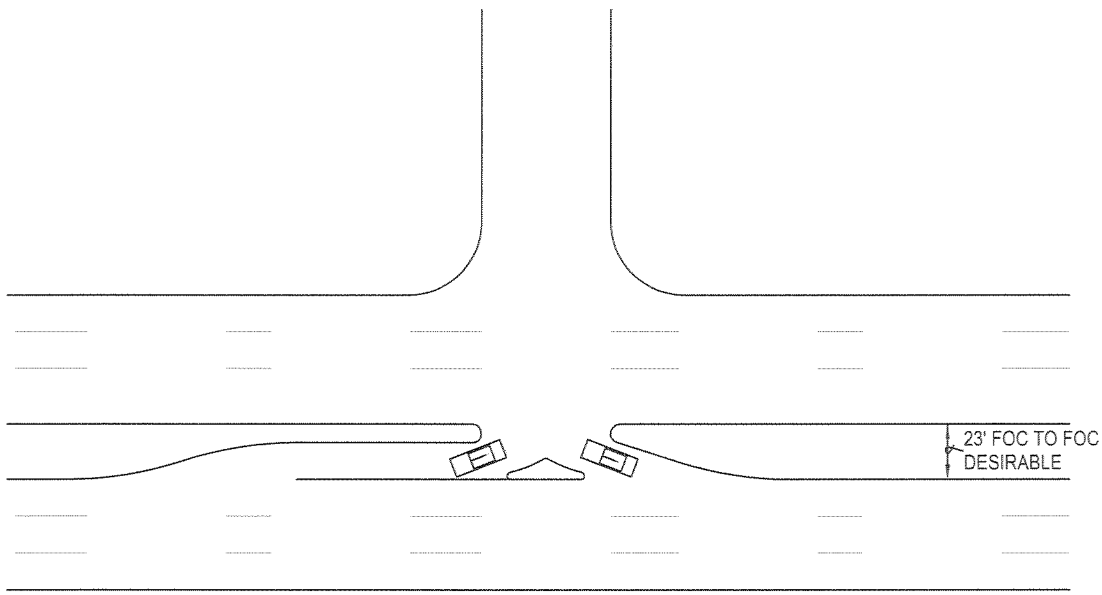


FIGURE 2-11

TYPICAL MEDIAN APPLICATION, CHANNELIZED "T"

2.5.3 Median Width

The width of a median is its most important geometric design consideration. Table 2-2 indicates widths necessary to accomplish certain functions, based on the passenger vehicle for primary design of crossing protection and U-turns.

Table 2-2
Recommended Median Widths

Function	Minimum (Feet)	Maximum (Feet)
Separation of opposing traffic	4*	6
Pedestrian refuge and space for traffic control	6*	16
Left-turn, speed–change and storage	14*	16
Crossing/entering vehicle protection	20	23
U-turns, speed-change, and storage	20	23
Channelized "T", speed-change, and storage	20	23-30

Source: City of Austin's Transportation Criteria Manual
**Cannot accommodate left-turn lanes, hence, such turns must be made from the through lanes.*

Any raised medians, and corresponding curb ramps used for pedestrian refuge and accessibility should meet requirements set forth in the Texas Accessibility Standards (TAS).

2.5.4 Median Break Spacing

The fewer the driveways on a major, urban street, the more effectively it will serve its primary function. Spacing should be maintained between driveways and intersections appropriate to the character of the driveway and roadway.

Driveway spacing should allow reasonable deceleration of vehicles approaching on the street and acceleration by vehicles entering the street. Median breaks for driveways should not be contemplated unless sufficient length is available to accommodate deceleration tapers and storage lengths. Table 2-3 reflects median and median break criteria. This criteria is based on the National Cooperative Highway Research Program (NCHRP) Report No. 93.

Full-function median opening on major arterials should be allowed only where minimum spacing for signalized intersections are practicable. At intermediate locations along major arterials, limited-function openings may be provided at the spacing listed in Table 2-3.

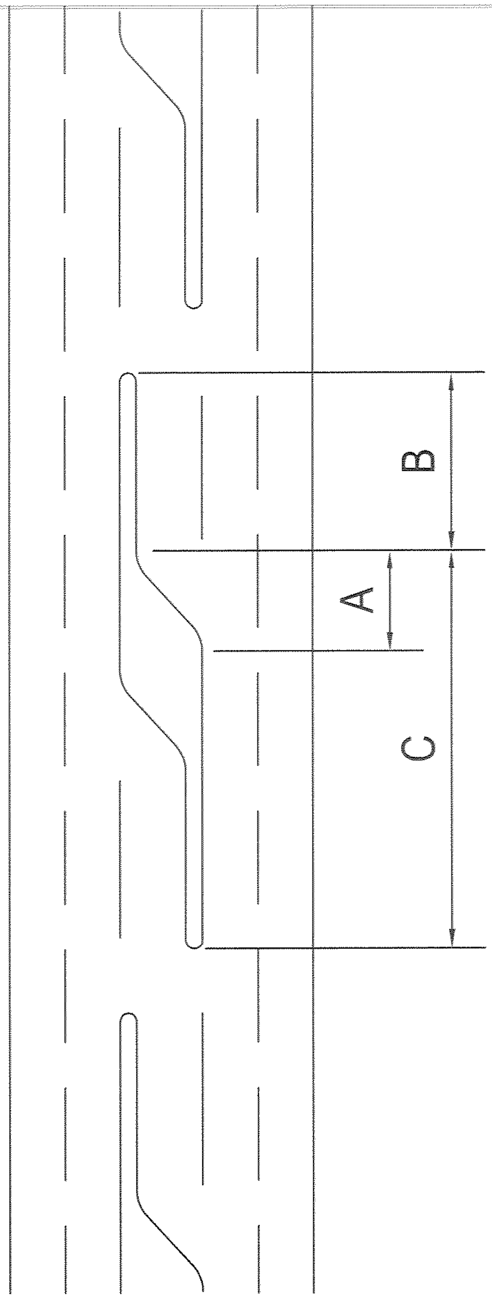
High volume driveways on major arterials should only be located opposite streets or other driveways when the minimum spacing requirements for signalized locations are met. Otherwise, T-intersection configurations should be designed. When driveways area located opposite street intersections the two should have compatible design elements.

On streets other than major arterials, full functional median openings area acceptable at the spacing listed in Table 2-3. On both major and minor arterials, access to public streets will have priority over access to private property.

Table 2-3
Median Opening Criteria

Design Speed (mph)	Minimum Spacing* Distance 'c' From Figure 2-12		Minimum spacing with 100 feet of left turn storage Requirement**		Minimum spacing with 150 feet of left turn storage requirement***	
	Absolute (ft)	Desirable (ft)	Absolute (ft)	Desirable (ft)	Absolute (ft)	Desirable (ft)
30	200	350	300	450	350	500
35	250	425	350	525	400	575
40	300	500	400	600	450	650
45	350	600	450	700	500	750
50	450	750	550	850	600	900

** Plus storage length based on peak hour volumes (see Table 2-4).*
*** Minimum storage when turning into a local street.*
**** Minimum storage when turning into a collector or an arterial street.*



DISTANCE A = BAY TAPER FROM
FIGURE 2-15
DISTANCE B = STORAGE LENGHT
FROM TABLE 2-4
DISTANCE C = REQUIRED SPACING
FROM TABLE 2-3

FIGURE 2-12

MEDIAN BREAKS

2.6 TURN LANES

The main purpose of a turn lanes is to provide storage space for the left turning vehicles and to separate decelerating vehicles, anticipating making a turn at the intersection, from the main lane vehicles. This helps in maintaining the capacity of the through lane traffic, and reduce vehicular conflicts at intersections of two (2) major streets. Storage lengths should be 150 feet then turning into a collector or an arterial street and 100 feet when turning into a residential street. At unsignalized intersections the storage length is based on the volume of vehicles anticipated to arrive at every two-minute period within the peak hour, and the vehicle length is assumed to be 20 feet. At signalized intersections, the storage length for left turning vehicles depends on the cycle length, signal phasing, and rate of arrivals and departures. Table 2-4 provides the minimum storage lengths for left turn bays.

Dual left turn and right turn lanes should be provided only when the volumes on the turning lanes exceed the capacity of a single lane and only if there are two receiving lanes on the cross street. For dual left and right lanes from a one-way street, the inside lane should be a mandatory turn lane.

Table 2-4
Storage Length for Left Turn Bays

* $L_{max\,(av)}$	Single Left Turn Lane	Dual Left Turn Lane
0	0	-
6	150	-
8	200	-
10	250	-
12	300	200
14	340	200
16	370	200
17	400	300
18	425	300
20	450	300
21	475	300
22	500	300
23	525	300
24	550	300
25	575	350

* $L_{max\,(av)} = 5.5\,(L_{avg}{}^{0.58})$ *(based on average conditions)*
Source: Research Report 258-1, University of Texas Center for Transportation Research, 1984

Storage lengths exceeding 400 feet should be discouraged. All proposals for turn bays exceeding 400 feet will require the approval of the City Engineer.

2.7 CHANNELIZATION

Channelization uses pavement markings, raised islands, or other suitable means separate and regulate conflicting traffic movement into definite travel paths for safety of both vehicles and pedestrians. The objectives of intersection channelization are to ensure efficient traffic movement, increase capacity, and improve safety.

2.7.1 CHANNELIZATION PRINCIPLES

The following principles shall be considered at each individual intersection when applying channelization. If disregarded, the objectives of channelization may not be achieved, resulting in a design which may be hazardous and inefficient.

2.7.1.1 Reduce the area of conflict; large paved intersectional areas invite hazardous vehicle and pedestrian movements.

2.7.1.2 When traffic streams cross without merging and weaving, make the crossing at or near right angles. If traffic signal control is planned, the crossing angle may be less than right angle with suitable signal design and visual clues.

2.7.1.3 Merge traffic streams at small angles.

2.7.1.4 The speed of a traffic stream entering an intersection may be controlled without funneling.

2.7.1.5 Provide refuge (shadowing) for turning and crossing vehicles where possible and necessary with channelization.

2.7.1.6 Use channelization to separate conflict points within an intersection.

2.7.1.7 Block prohibited turns with well-delineated channelization.

2.7.1.8 Channelization may provide locations for the installation of essential traffic control devices to enhance their visibility.

2.7.2 ADA REQUIREMENTS

Raised islands, including refuge and curb ramps, should meet all requirements set forth in the TAS.

2.8 TAPERS

The following design criterion is taken from the Institute of Transportation Engineers report, Guidelines for Urban Major Street Design, 1983 and the Uniform Design Standards Manual of the Metropolitan Transit Authority of Harris County. In order to discuss the various elements of turn-lane channelization, a standard terminology must be established. Figure 2-13 through 2-16 show design elements of a taper.

2.7.1 Terminology

The following section outlines terminology for tapers.

2.7.1.1 An approach taper is that portion of the roadway geometry from the point where all approaching traffic must shift laterally, to the beginning point of the bay taper. The taper length is a direct product of slope angle, which is most related to expected operating speeds.

2.7.1.2 A bay taper is from the edge of the adjacent through traffic lane to the beginning of the full width of the turn storage lane.

2.7.1.3 A storage length is the distance from the end of the bay taper to the intersection nose or stop line.

2.7.1.4 The intersection nose is the radius or distance from the end of the storage bay to the near edge of the cross-route exit lane for the left-turning vehicle. For left-turn bays the cross-route exit reference is normally the centerline of an unchannelized two-way street or the far edge of the median in a channelized street.

2.7.1.5 A departure taper of a left-turn bay is from the point where through traffic beyond the intersection begins a lateral shift to the left, to the point where the through lane is adjacent and parallel to the centerline.

2.7.2 Types of Tapers

The following section describes criteria for the various types of tapers.

2.7.2.1 In a study by the Department of Public Works, County of Sacramento, California, two equations were tested to establish approach taper lengths.

$$L = W*s \qquad \text{(Eq. 1)}$$
$$L = (W*S*S)/60 \qquad \text{(Eq. 2)}$$

Where:
L = Length in feet
S = Design Speed – Speed in miles per hour
W = Lateral offset in feet from centerline (double yellow)

This study included recording the speed of vehicles at the beginning and end of the approach taper and noting where the driver stays between the lane lines. Based on the results:

Equation 1 is recommended for posted speeds of 40 mph or less.

Equation 2 is recommended for posted speeds of 45 mph or greater.
See Figure 2-13 and Figure 2-14 for approach tapers.

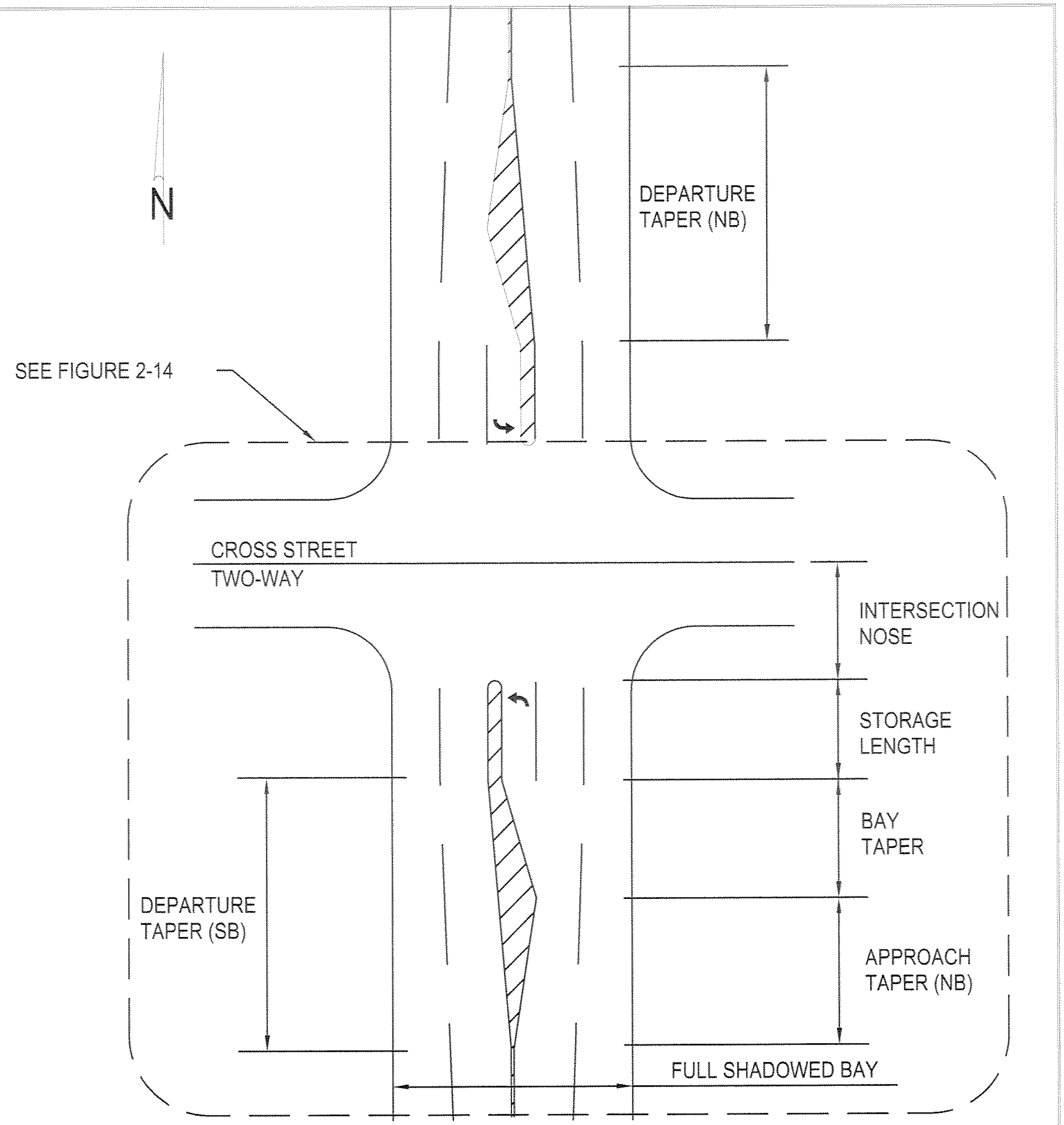
2.7.2.2 For bay tapers, the transition lengths and the corresponding curve radii vary widely because of the different philosophies regarding the type of entry a turning vehicle should make. Some feel that the transition should be smooth and gradual. Thus, in these areas, large radii and long transition lengths are used. This type of design also is favored because of the ease of street cleaning operations. The design of bay tapers should conform to standards indicated in Figure 2-15.

2.7.2.3 There are two different designs for developing the departure taper. The variation relates to the point of the start of the taper in a channelization that provides a full shadowed lane. The first variation starts the taper at the point of full median width, while the other begins the taper at the end of the storage lane, as shown in Figure 2-14. Beginning at the end of the storage lane and ending at the beginning of the approach taper provides a flatter angle which is easier for a vehicle to negotiate. It requires less widening and/or parking restrictions and is recommended as the desirable design guide.

2.7.2.4 Acceleration lanes are seldom used along urban major streets. However, when they are used, the transition taper design may be the same as for an approach taper. Many agencies utilize the rule of thumb that allows one (1) foot of lateral displacement per mph of the roadway into which the vehicle is emerging (L=W*S). Thus, a 12-foot (W) acceleration lane merging with a street having a speed of 30 mph (S) would produce a 360-foot taper. A deceleration lane is actually a right-turn lane (or left if on a one-way roadway) and therefore should be designed in accordance with bay-taper principles.

2.7.2.5 Through-lane Tapers- When all traffic must transition to the left or right, the design represents an approach-taper condition. For an added through lane approaching an intersection, the transition into the lane may be made by either an approach or a bay-taper design. However, the termination of the added lane beyond the intersection (a lane drop) should be handled by the approach-taper type of design.

2.7.2.6 Tapers on Horizontal Curves - For a left-turn bay, the taper may be longer if the horizontal curve direction is to the driver's left. Conversely, the tapers may be shorter if the curve is to the driver's right. Figure 2-16 shows the reason for this, based upon the deflection angle requires from a tangent line to the curve. Adjustment of "standard" local design criteria is most appropriate for turn-lane tapers located on curves of 500 foot radius or less. The adjustment can be determined graphically.



SOURCE:
ADAPTED FROM ITE, GUIDELINES FOR URBAN MAJOR STREET DESIGN, 1983.

FIGURE 2-13

DESIGN ELEMENTS OF LEFT-TURN BAY CHANNELIZATION

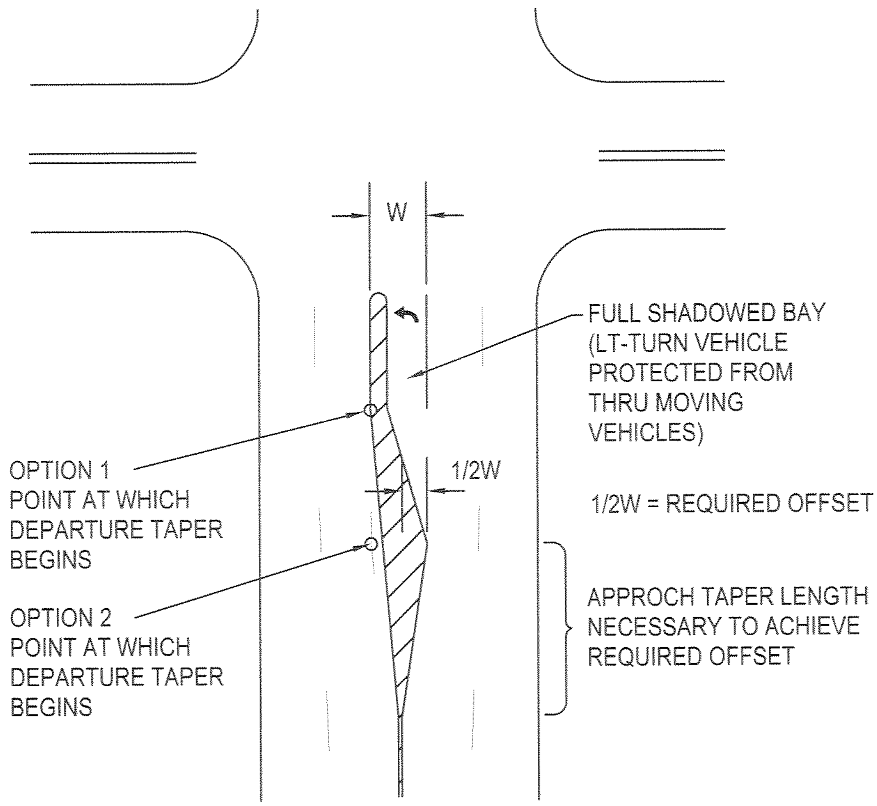
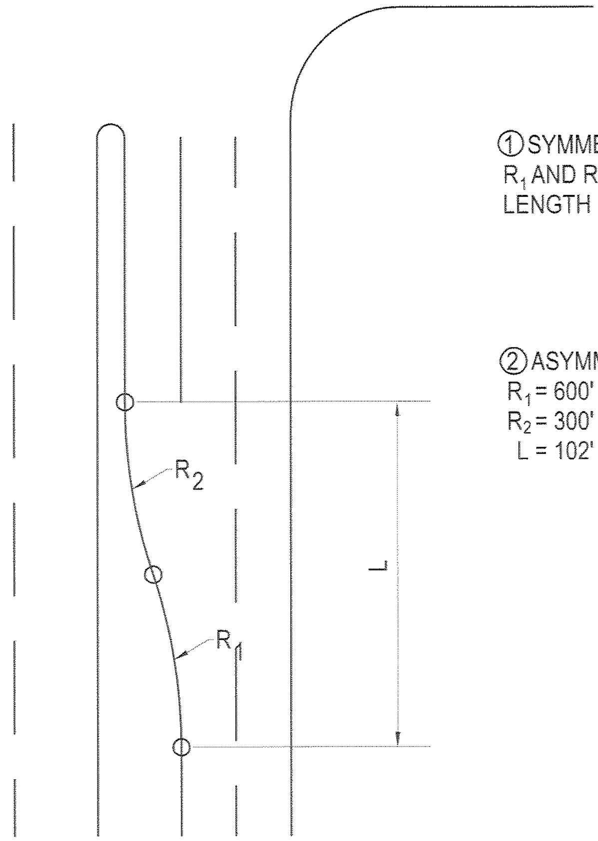


FIGURE 2-14

LEFT-TURN BAY
CHANNELIZATION

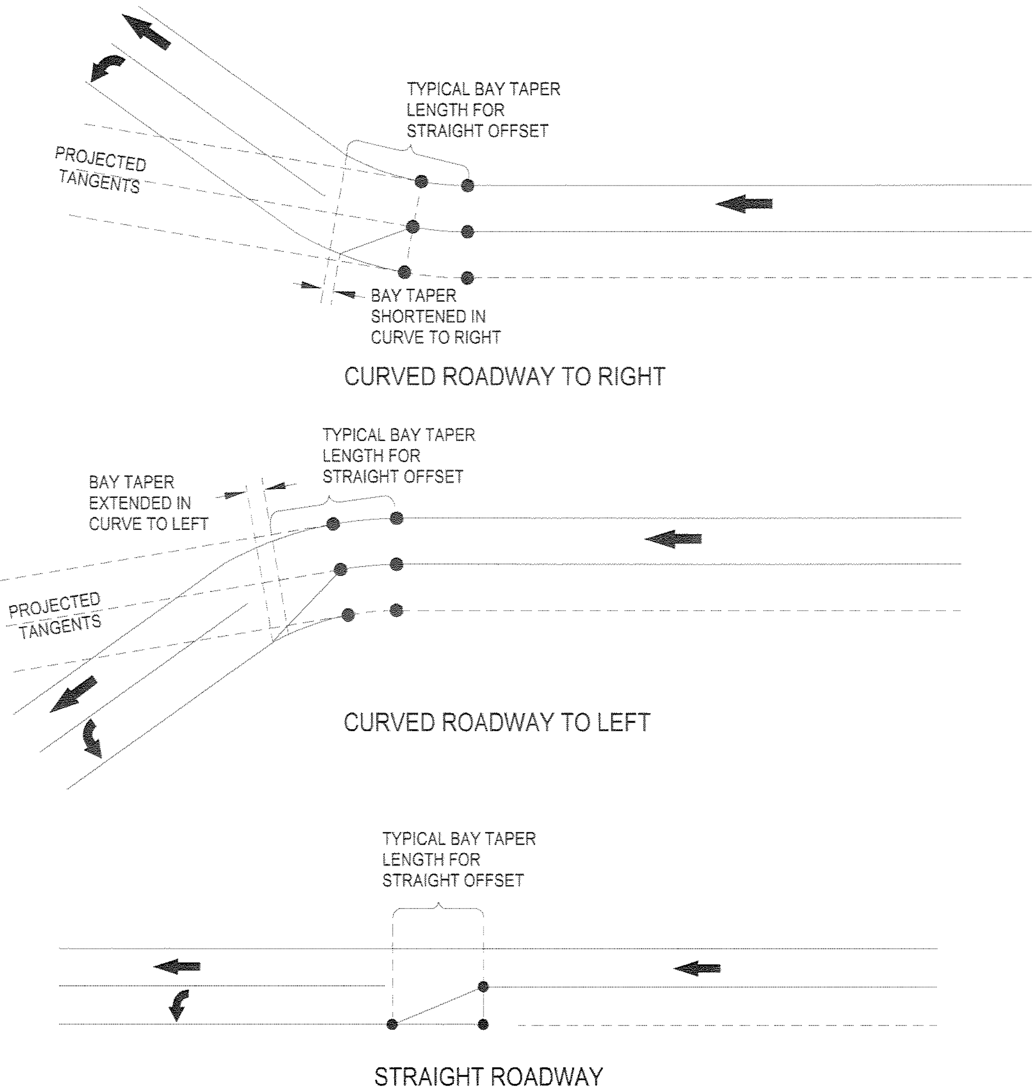


① SYMMETRY OPTION
R_1 AND R_2 = 300'
LENGTH = 118'

② ASYMMETRICAL OPTION
R_1 = 600'
R_2 = 300'
L = 102'

FIGURE 2-15

BAY TAPER DESIGN



SOURCE:
ADAPTED FROM ITE, GUIDELINES FOR URBAN MAJOR STREET DEGIGN, 1983.

FIGURE 2-16

EFFECT OF CURVES ON BAY TAPERS

2.9 Sidewalks

Sidewalks shall be constructed in all new subdivision developments and in street redevelopment projects.

2.9.1 Dimensions

Section 7.2.1.6 on bicycle and pedestrian elements should be consulted for sidewalk dimensions.

2.9.2 Obstructions

Where utility poles, fire hydrants, or other utility installations occur within the sidewalk width, the sidewalk shall be offset around the obstacle at its full width. Exceptions or modifications shall be approved by the City Engineer prior to construction.

2.9.3 Curb Ramps

Depending upon pedestrian traffic and existing roadway geometrics at a particular intersection, one or more curb ramps shall be constructed at the intersection. The Texas Accessibility Standards should be referred to for design details.

2.10 Lighting at Intersections

Lighting may affect the safety of highway and street intersections, as well as efficiency of traffic operations. In urban and suburban areas where there are concentrations of pedestrians and roadside and intersectional interferences, fixed-source lighting tends to reduce night time crashes. Intersections with channelization, particularly multiple–road geometrics should include lighting. Large channelized intersections need illumination because of the higher range of turning radii that are not within the lateral range of vehicular headlight beams.

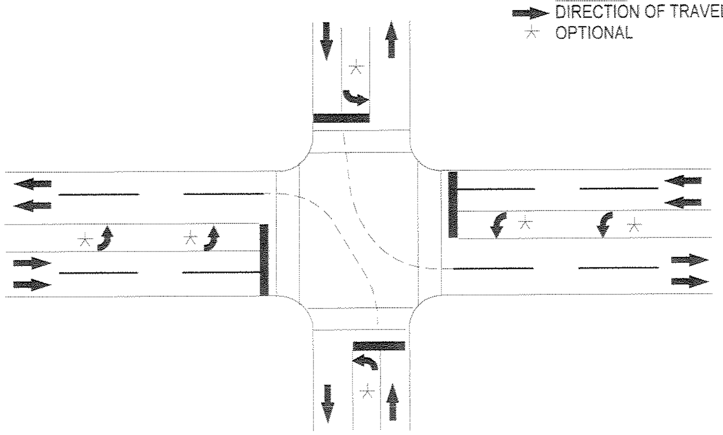
Planned locations of intersection luminaire supports should be designed in accordance with current roadside safety concepts. Design guidance can be obtained from Transportation Research Board's NCHRP Report 152, <u>Warrants for Highway Lighting</u>, 1974 and the AASHTO Roadside Design Guide. Refer to TxDOT Austin District standards and specifications for luminaire design.

2.11 Pavement Markings

Pavement markings identify and direct attention to the location of an intersection and advise drivers, bicyclists, and pedestrians to take appropriate action. The 2003 Texas Manual on Uniform Traffic Control Devices should be consulted to determine the type and placement of pavement markings at an intersection. Typical pavement markings are shown in Figure 2-17.

TYPICAL DOTTED LINE MARKINGS TO EXTEND LONGITUDINAL LANE LINE MARKINGS

LEGEND
DIRECTION OF TRAVEL
OPTIONAL



NOTE: LANE LINE EXTENSIONS MAY BE DOTTED
OR SOLID LINES

TYPICAL DOTTED LINE MARKINGS TO EXTEND LONGITUDINAL CENTER LINE MARKINGS

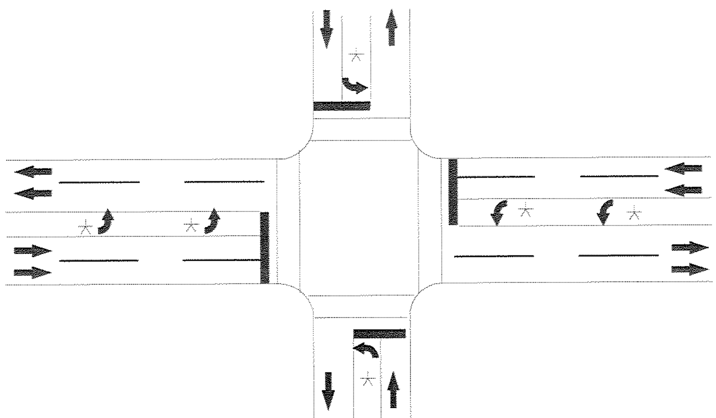


FIGURE 2-17

TYPICAL PAVEMENT
MARKING
APPLICATIONS

2.12 Marginal Streets

Where a subdivision has frontage on an arterial street, the planning and zoning commission may require marginal access streets to be provided on both sides or on the subdivision side of the arterial street, if the arterial street borders the subdivision, unless the adjacent lots back up to, side up to or front with extra depth and access off an alley and provide some other means of restricting individual access.

2.13 Street Layout

Adequate streets shall be provided by the subdivider and the arrangement, character, extent, width, grade and location of each shall conform to the comprehensive plan and shall be considered in their relation to existing and planned streets, topographical conditions, public safety and convenience and in their appropriate relationship to the proposed uses of land to be served by the streets. The street layout shall be devised for the most advantageous development of the entire neighborhood.

2.14 Relation to adjoining street system

Where necessary to the neighborhood pattern, existing streets in adjoining areas shall be continued and shall be at least as wide as the existing streets and in alignment with the existing streets.

2.15 Projection of Streets

Where adjoining areas are not subdivided, the arrangement of streets in the subdivision shall make provision for the proper projection of streets into the un-subdivided area.

3.1 General

The information provided in this Chapter was obtained from AASHTO's 2001, A Policy on Geometric Design of Highways and Streets , 2003 Texas Manual on Uniform Traffic Control Devices (TMUTCD), 1999, ITE Traffic Engineering Handbook, 1999,TxDOT's Traffic Signals Manual, and 2004 TxDOT's Access Management Manual. Traffic control devices consist of signs, pavement markings, and traffic signals. Pedestrians, cyclists, and drivers are dependent upon traffic control devices to provide information, guidance, and warnings. Therefore, it is important that all traffic control devices are standard and uniform in appearance to provide safe and efficient traffic operations.

3.2 Signs

In order to install an unsignalized traffic control device, such as a "Yield" sign or a "Stop" sign, an analysis of traffic and pedestrian characteristics should be performed at the intersection location to determine if installation of a sign at that particular location is justified. All signage and placement of signs shall conform to the standards set forth in the most recent version of the TMUTCD.

3.3 Pavement Markings

All pavement markings shall conform to the standards set forth in the most recent version of the TMUTCD. Typical pavement markings are shown in Figure 2-17.

3.4 Traffic Signals

The following section describes traffic signal warrants and elements to be included within traffic signal designs.

3.4.1 Traffic Signal Warrants

Installation of traffic signals are regulated and must meet State criteria outlined in the most recent version of the TMUTCD. Traffic operations, volumes, pedestrian and bicyclist needs, and other factors, coupled with engineering judgment, are provided in this series of signal warrants. These warrants define the minimum conditions under which installation of a traffic control signal are justified. A signal warrant study shall be performed and submitted to the City Engineer for approval of a traffic signal. Although only one warrant is necessary to justify installation of a traffic signal, the City Engineer has discretion on allowing installation of the signal based on how it will affect the overall transportation network.

3.4.2 Location of Signals

The exact location of a traffic signal depends on numerous conditions including grades, curves, operating speeds, location of adjacent signals, etc. For City roadways, signals shall be spaced at least 1,000 feet apart as per the TMUTCD and allow for platooning and in order to provide effective coordination. For TxDOT roadways, signals shall be spaced at least 2,740 feet apart. Deviation from these requirements shall be approved by the City Engineer.

3.4.3 Traffic Signal Design

All decisions on the components used in the installation of a traffic signal shall be approved by the City Engineer. In general, refer to the Texas Department of Transportation's Austin District standards and specifications to for detailed design standards.

3.4.4 Traffic Signal Equipment

For reference, below is a checklist of the considerations for equipment required in a traffic signal design. Decisions on the exact types of equipment shall be made by the City Engineer.

1. Pole type for signal head mounting
    a. Span-wire
    b. Mast-arm
    c. Foundation
2. Vehicle detection
    a. Loop detectors (sawcut)
        1. Number of loops
        2. Size of loops
        3. Spacing of loops
    b. Video detectors
        1. Number of cameras
        2. Location of cameras
        3. Direction of cameras
3. Signal Heads and Back Plates
    a. Size of vehicle signal heads
    b. Use of backplates
    c. Pedestrian heads
4. Wiring details
    a. Power source
    b. Type of wiring for each piece of equipment
    c. Overhead wiring or underground conduit
    d. Number and size of conduits
    e. Interconnection with coordinated traffic control system
5. Traffic signal controller
    a. Type of controller
    b. Location of controller (preferably on the right corner of a minor street approach)
    c. Foundation
6. Pull boxes (Ground Boxes)
    a. Type
    b. Size
    c. Locations
7. Illumination
    a. Location
    b. Number
    c. Wiring specifics

8. Pavement markings
9. Pedestrian Equipment
   a. Type of pedestrian heads
   b. Pedestrian detection (push buttons)
   c. Signing
   d. Curb ramps and sidewalk connectivity

3.4.5 Additional Signal Design Considerations

The following outlines additional issues that shall be considered for traffic signals.

3.4.5.1 Underground Utilities - Details on the existing and/or proposed right-of-way and all overhead and underground utilities shall be shown on traffic signal design plans. In addition, the location of all underground utilities shall be determined by contacting Texas One Call prior to performing any work at an intersection.

3.4.5.2 Coordination of Traffic Control Signals - Efforts should be made to coordinate traffic signals within 0.5 miles of one another along a major route or network. Coordination could be performed through the use of a hard wire connection or radio communication.

3.4.6 Cash Contribution

The City, in its sole discretion, may accept cash contributions, in lieu of construction of a traffic signal, from developers for signals that are required because of their developments. The equivalent cash contribution will be based upon the development's proportionate share of the costs of the improvements. Any funds accepted by the City shall be earmarked for construction of the improvements for which the contribution was made.

The fixed cost for installation of a traffic signal shall be determined by the City Engineer. The cost shall include the cost for the traffic signal, controller, all the appurtenances, hardware, software, timing plans, and maintenance.

3.4.7 Advanced Funding Agreements

An advanced funding agreement will be necessary for situations in which a traffic signal or other roadway improvement is required to accommodate a project which accesses a state roadway. In these situations, the applicant shall provide the cash contribution to the City, and the City in turn will provide the cash contribution to TxDOT through an Advanced Funding Agreement established between the City and TxDOT. In the case of signalization, both TxDOT and the City Engineer must approve a traffic signal before it can be installed.

3.4.8 Responsibility and Maintenance

Prior to the installation of any traffic signal, responsibility for the maintenance of the signal shall be clearly established.

4.1 General

This section provides guidelines for geometrics, signing, pavement marking, illumination, traffic signals, and preemption at railroad crossings at roadway. This information was obtained from the 2003 Texas Manual on Uniform Traffic Control Devices (TMUTCD) and AASHTO's – Policy on Geometric Design of Highways and Streets, 2001 (AASHTO's Green Book).

4.2 Railroad Crossing Geometrics

In order to provide safe and efficient operations for rail and vehicles, it is important to design railroad crossings with appropriate horizontal and vertical alignment. Approach sight distance shall be provided along the road and railroad tracks, to allow drivers to perceive the oncoming train and react in sufficient time. The roadway width at a railroad crossing shall be the same width as the approach roadway.

4.2.1 Horizontal Alignment

A roadway shall intersect the railroad at a right angle, wherever possible, with no nearby intersections or driveways, in order to enhance rideability, improve the driver's view of crossing tracks, reduce conflicting movements of vehicular traffic, and enhance safety of pedestrians and bicyclists.

Where a roadway that runs parallel with the railroad intersects a roadway that crosses the railroad, there shall be sufficient distance between the railroad and roadway intersection to enable traffic in all directions to move expeditiously. Where the distance between the railroad and roadway intersection is not sufficient, the following should be considered:

- Interconnection of a traffic signal with the railroad signal to enable vehicles to clear the grade crossing, when the train is approaching.
- Placement of a "Do Not Stop on Track" sign on the roadway approach to the grade crossing.

Refer to the most recent version of AASHTO's Green Book for additional information.

4.2.2 Vertical Alignment

The intersection of a roadway with an at-grade railroad crossing should be made as level as possible to provide adequate sight distance, rideability, breaking, and acceleration distances. Refer to the most recent version of the AASHTO's Green Book for additional information.

4.3 SIGNING

Signs identify and direct attention to the location of a railroad crossing and advise drivers, bicyclists, and pedestrians to take appropriate action. Figure 4-1 shows detailed signing requirements at roadway and railroad grade crossings. Refer to the most recent version of the TMUTCD for additional information on the type and placement of signs at highway-railroad grade crossings.

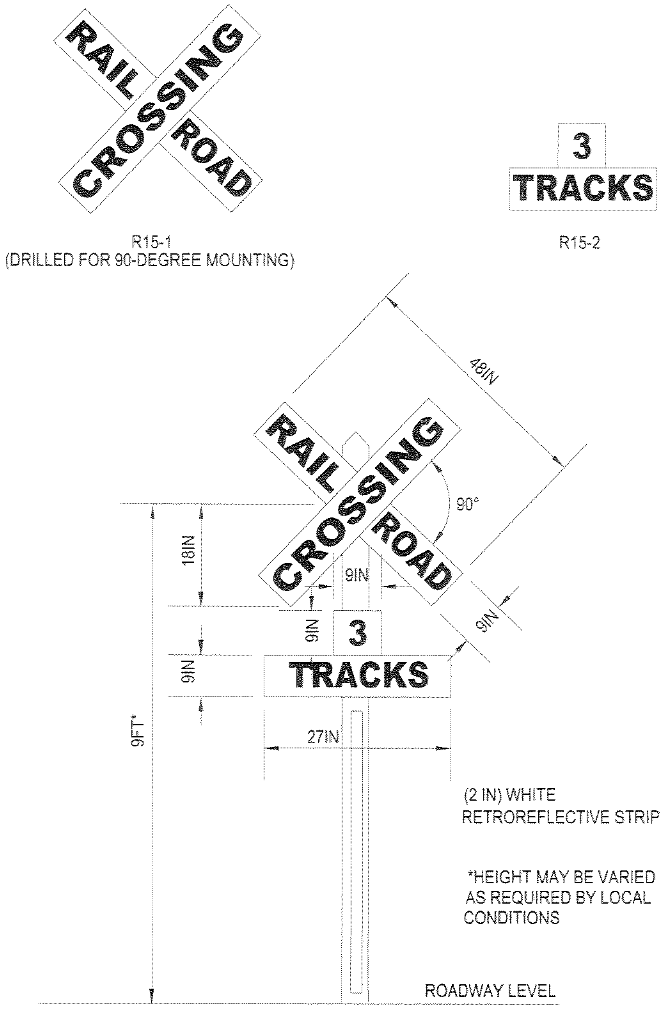
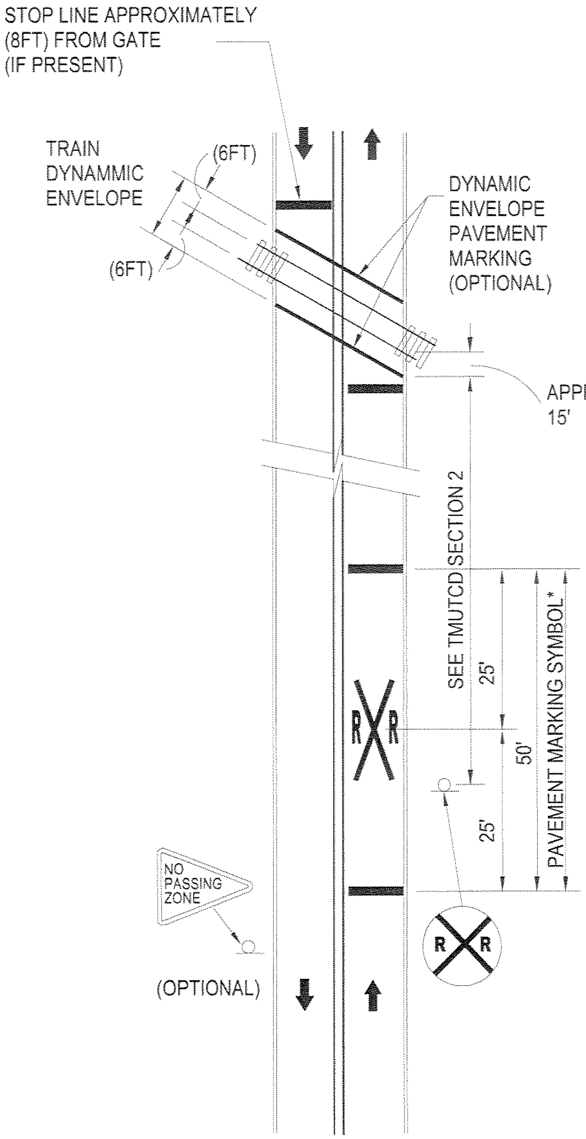


FIGURE 4-1

HIGHWAY-RAIL GRADE CROSSING (CROSSBUCK) SIGN

4.4 Pavement Markings

Pavement markings identify and direct attention to the location of a railroad crossing and advise drivers, bicyclists, and pedestrians to take appropriate action. Typical pavement markings of roadway and railroad grade crossings are shown in Figure 4-2. Refer to the most recent version of the TMUTCD for additional information on the type and placement of pavement markings at railroad grade crossings.



A THREE-LANE ROADWAY SHOULD BE MARKED WITH A CENTERLINE FOR TWO-LANE APPROACH OPERATION ON THE APPROACH TO A CROSSING.

ON MULTI-LANE ROADS, THE TRANSVERSE BANDS SHOULD EXTEND ACROSS ALL APPROACH LANES, AND INDIVIDUAL RXR SYMBOLS SHOULD BE USED IN EACH APPROACH LANE.

*WHEN USED, A PORTION OF THE PAVEMENT MARKING SYMBOL SHOULD BE DIRECTLY OPPOSITE THE ADVANCE WARNING SIGN (W10-1). IF NEEDED, SUPPLEMENTAL PAVEMENT MARKING SYMBOL(S) MAY BE PLACED BETWEEN THE ADVANCE WARNING SIGN AND THE CROSSING, BUT SHOULD BE AT LEAST (50FT.) FROM THE STOP LINE.

NOTE: IN AN EFFORT TO SIMPLIFY THE FIGURE TO SHOW WARNING SIGN AND PAVEMENT PLACEMENT, NOT ALL REQUIRED TRAFFIC CONTROL DEVICES ARE SHOWN.

FIGURE 4-2

TYPICAL PLACEMENT OF WARNING SIGNS AND PAVEMENT MARKINGS AT HIGHWAY-RAIL GRADE CROSSING

4.5 Illumination

Illumination at roadway and railroad grade crossings should be installed when an engineering study determines that adequate nighttime visibility of the train and highway is required. Types, location, and placement of luminaires at these crossings are contained in the American National Standards Institute's (ANSI) "Practice for Roadway Lighting RP8" available from the Illuminating Engineering Society. Refer to this manual for additional information.

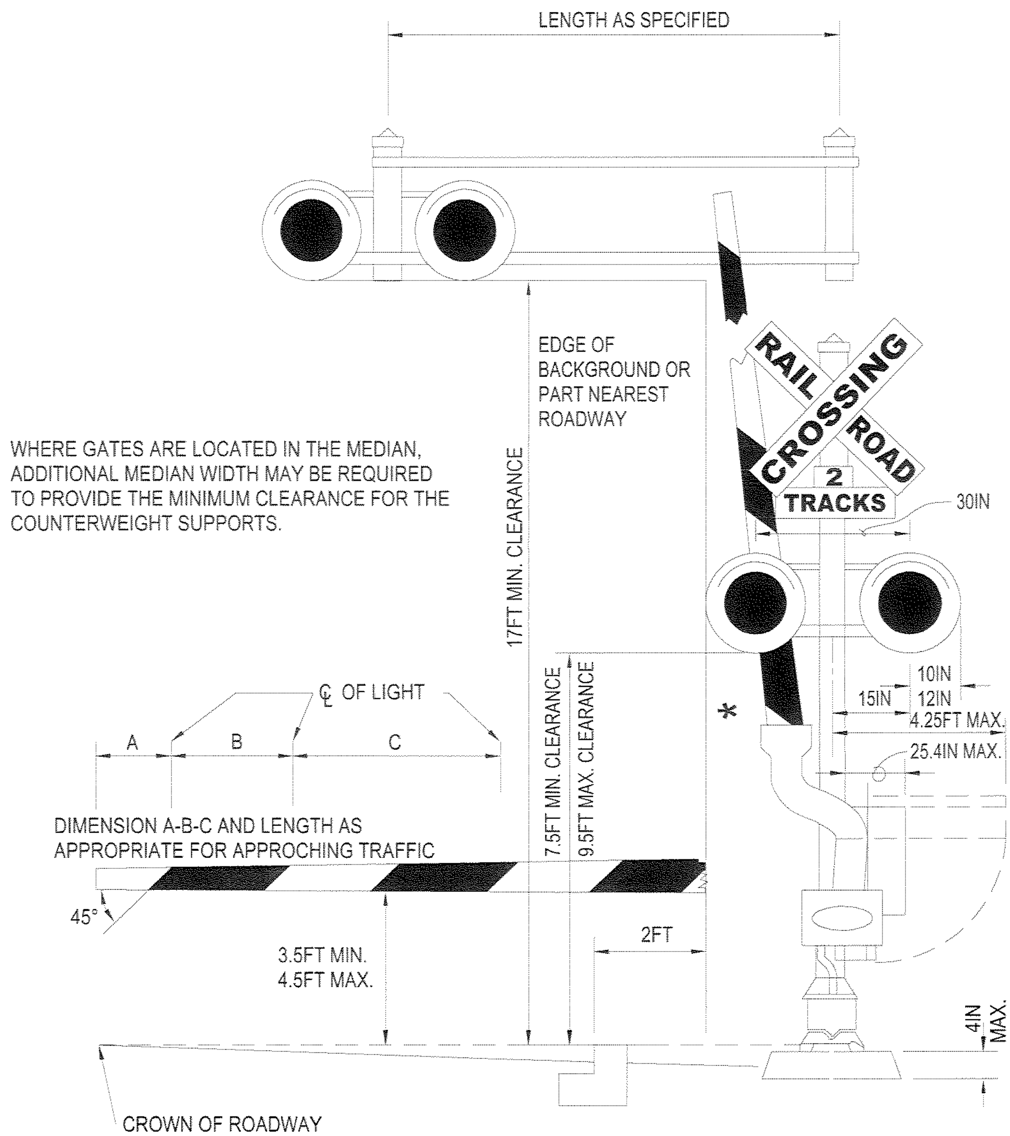
4.6 Flashing-Light Signals, Gates, and Traffic Control Devices

Flashing-light signals and gates inform drivers, bicyclists, and pedestrians of the approach or presence of trains, locomotives, or other railroad equipment at railroad crossings. Figure 4-3 shows clearances for post-mounted flashing-light signals and structures, and an automatic gate assembly. Refer to the most recent version of the TMUTCD for appropriate design criteria.

4.7 Traffic Control Signals Near Highway-Railroad Grade Crossings

If a railroad crossing is equipped with a flashing-light signal system and is located within 200 feet of an intersection or a mid-block location controlled by a traffic signal, the traffic signal shall be provided with railroad preemption in accordance with the TMUTCD.

If railroad preemption is provided, the normal sequence of the traffic signal shall be preempted upon the approach of the trains to avoid entrapment of vehicles on the railroad crossing.



* FOR LOCATING THIS REFERENCE LINE AT OTHER THAN CURB SECTION INSTALLATION, SEE SECTION 8B.02

FIGURE 4-3

CLEARANCE FOR POST MOUNTED FLASHING-LIGHT STRUCTURE

5.1 General

Providing efficient driveway design, and planning the number and location of access points will help to ensure safe and efficient flow of traffic and improved service to adjacent properties. This section provides guidelines on driveways and access management.

5.2 Type of Driveways

There are three types of driveways: residential driveways, commercial driveways, and temporary driveways.

5.2.1 Residential Driveways

Residential driveway approaches are located solely for access to individual single-family, duplex, or townhouse structures.

5.2.2 Commercial Driveways

Commercial driveway approaches are located solely for access to all structures other than residential driveways or temporary driveways, described below.

5.2.3 Temporary Driveways

A temporary driveway is intended to provide vehicular access to a property that abuts a roadway, which is not yet permanently constructed. The driveway shall be reconstructed to a residential or commercial driveway within 60 days after the construction of the abutting street has been completed.

Figure 5-1 depicts general driveway layouts.

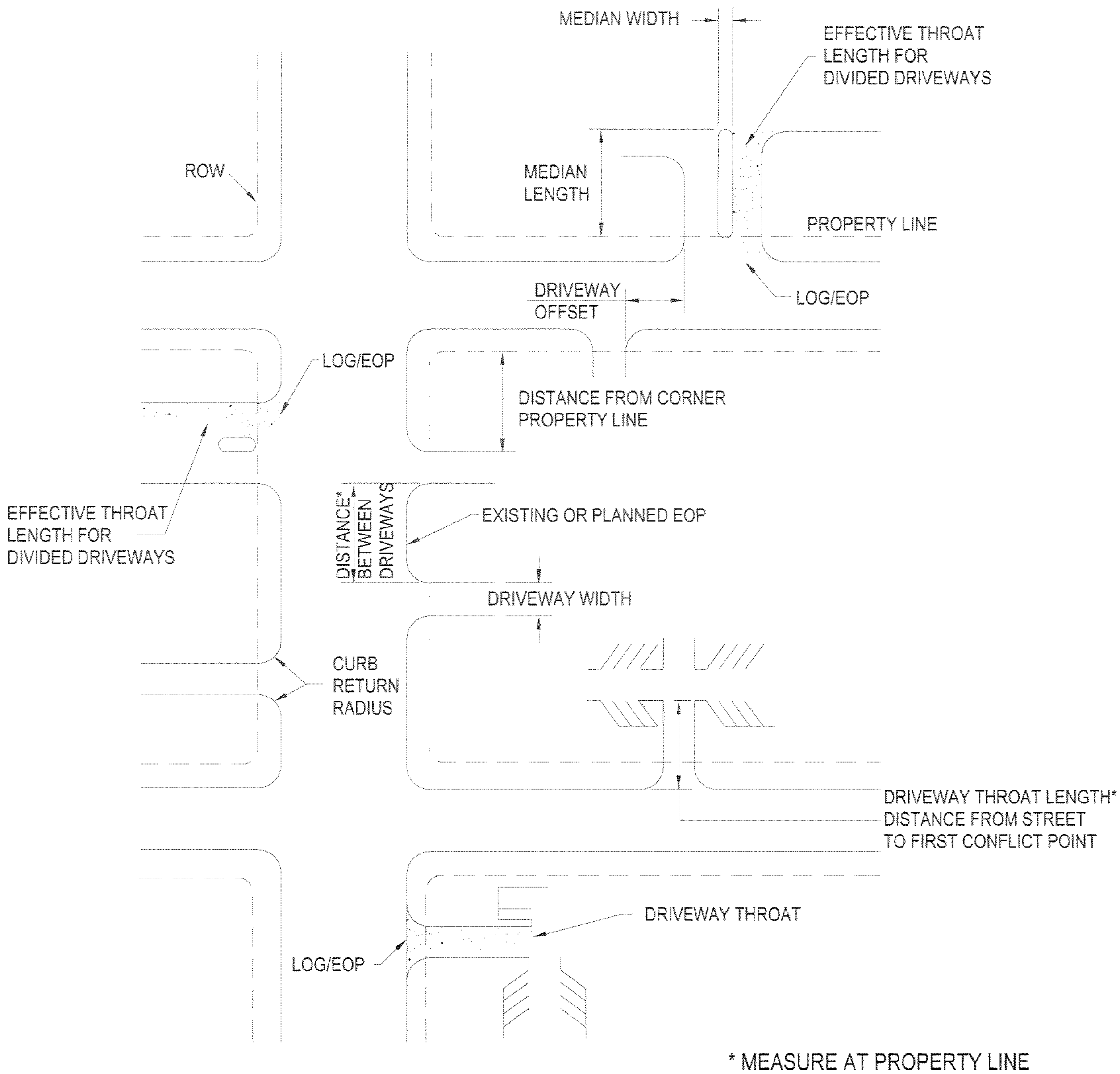


FIGURE 5-1

GENERAL DRIVEWAY LAYOUT

5.3 Driveway Design Criteria

The following design criteria shall be applied to all driveways, unless specified otherwise.

5.3.1 Alley Access

Access to alleys shall require approval by the City Engineer.

5.3.2 Driveway Angle of Intersection

The angle of driveway approach shall be consistent with Chapter 2.4.2.

5.3.3 Intersection of One-Way and Two-Way Driveways

The City Engineer shall have discretion on the use of one-way or two-way driveways intersecting one-way or two-way streets.

5.3.4 Joint Access

All driveways shall be constructed on the street frontage of the subject property, unless a joint access agreement is obtained from the adjacent property owner. The joint access agreement must indicate that maintenance of the joint use driveway is the responsibility of the lot owners served by the driveway provided.

5.3.5 Property Frontage

Driveways shall not exceed 70 percent of roadway frontage. Not more than two driveway approaches shall be permitted on any parcel of property with a frontage of 150 feet or less, except that additional openings may be permitted with the approval of the City Engineer for the necessity and convenience of the public.

5.3.6 Driveway Approaches in Existing On-Street or Head-In Parking Areas

Driveway approaches shall not be constructed in existing on-street angle or head-in parking areas unless all curb is restored to a standard location along the roadway in front of the premises.

5.3.7 Obstruction of Driveway Approaches

Driveway approaches shall not be constructed or designed so that standing or parked vehicles may obstruct the driveway. If approved by the City Engineer, it may be feasible to modify parking zones to permit driveway construction in unique circumstances.

5.3.8 Premises Used as a Motor Bank

Premises used as a motor or drive-through bank may have driveway approaches and queue storage as approved by the City Engineer. The approaches shall be utilized for drive facilities and shall not be used for angle or head-in parking.

5.3.9 Drainage

Approaches shall be designed to prevent the entrance of water from the street onto private property, except that a drainage system may be provided within the property to handle water coming from the street. Driveway approaches constructed below the street curb grade shall be deemed substandard, and the permit applicant/property owner is required to provide a certificate by a state registered Professional Engineer certifying to the adequacy of the drainage system provided within the property to handle water coming from the street as a result of the substandard construction.

5.3.10 Minimum Centerline Offset of Adjacent Intersections With Commercial Driveways

The following criteria describe offsets of adjacent intersections with commercial driveways.

5.3.10.1 Driveway should either align with opposing streets or driveways or be offset. Centerlines of opposing 'T' intersections shall be 125 feet apart for driveway-local intersections, 150 feet for driveway-collector intersections, and 200 feet for driveway-arterial intersections. In case of jogged driveway-arterial intersections, greater offsets may be required, in order to allow for left-turn storage between intersections.

5.3.10.2 Alignment of driveways with opposing streets is discouraged for signalized intersections unless approved by the City Engineer. If approval is obtained, the driveway may be constructed without an apron and the driveway widths in Table 5-1 may be increased to match the width of the opposing street. Table 5-1 provides driveway spacing and corner clearance criteria for City roads. These criteria are minimum values. Effort should be made to consolidate driveways and provide greater spacing when possible.

Table 5-1
Minimum Driveway Spacing Criteria for City Roads

Driveway Type	Roadway Type			
	Residential or Neighborhood Collector (feet)	Commercial or Industrial Collector (feet)	Minor Arterial (feet)	Major Arterial (feet)
One-Way	50	75	150	150
Two-Way Undivided	75	100	200	200
Two-Way Divided	75	100	200	200

5.3.11 Throat Depths

A throat depth is the length of a driveway measured from the intersecting roadway to the first intersection or driveway aisle on the site. It is important to maintain adequate throat depths for driveways so that vehicles do not backup onto the intersecting roadway. Table 5-2 shows the design standards used in construction of residential and commercial driveways. The throat depth requirements shown in Table 5-2 may be reduced, if approved by the City Engineer after considering the following factors:

- Existing structures on the site;
- On-site circulation;
- Shallow lot depths or unusual lot configurations;
- Existing or potential traffic movement which have an adverse effect on traffic operations;
- Traffic volumes and classification of driveway and the intersecting street;
- Alternatives to the proposed design;
- For existing sites, the extent of redevelopment proposed.

Throat depths in excess of those shown in Table 5-2 may be required if justified by the finding in a Traffic Impact Analysis or Queuing Analysis.

5.3.12 Right-Turn Deceleration Lanes

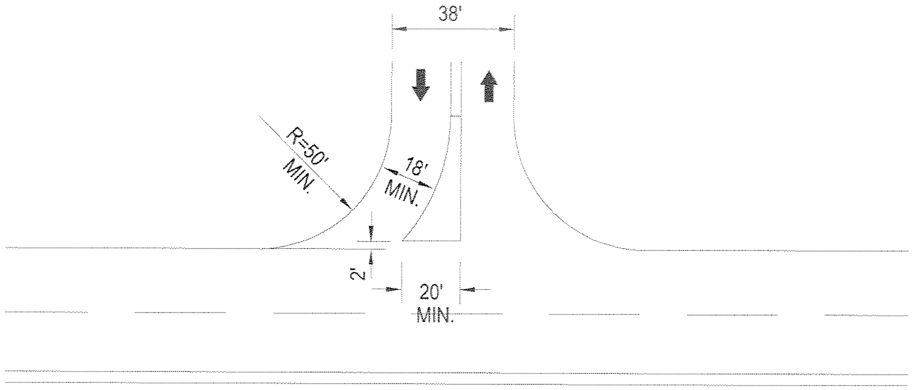
Right-turn deceleration lanes should be considered when right turn volumes exceed 100 vehicles during the peak hour at an intersection. Traffic volumes on the adjacent roadway and speeds should be factored into the determination for the need of the right-turn deceleration lane.

5.3.13 Limited Movement Driveways

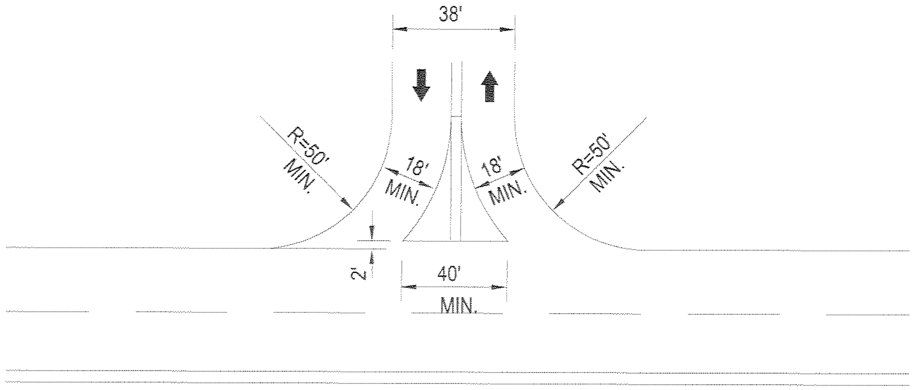
Limited movement driveways include right-in, right-out driveways, right-in, right-out, left-out driveways, and right-in, right-out, left-in driveways. Design criteria for limited movement driveways are shown in Figure 5-2. The City Engineer shall have discretion to limit movements at driveways based on traffic volumes, intersection geometry, or safety concerns.

Table 5-2
Design Criteria for Residential and Commercial Driveways

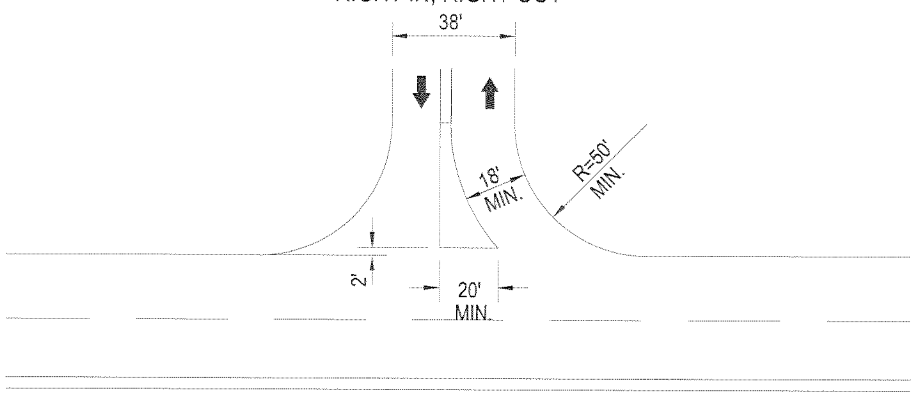
Design Criteria	Minimum	Desirable	Maximum
Residential - Single Family			
Width (feet)	10	18	20
Curb Return Radius (feet)	5	5	5
Throat Length (feet)	(Extend to property R.O.W. line as a minimum)		
Spacing Between Driveways (feet)	(Limit to one driveway per property)		
Residential - Duplexes And Townhomes			
Width (feet)	15	18	25
Curb Return Radius (feet)	5	8	10
Throat Length (feet)	(Extend to property R.O.W. line as a minimum)		
Spacing Between Driveways (feet)	20	-	-
Commercial			
Width (feet)	24	30	45
Curb Return Radius (feet)	10	15	30
Throat Length (feet)	40	50	75
Spacing Between Driveways (feet)	(See Table 5-1)		



RIGHT IN, RIGHT OUT, LEFT IN



RIGHT IN, RIGHT OUT



RIGHT IN, RIGHT OUT, LEFT OUT

SOURCE: ADOPTED FROM THE CITY OF LAKEWOOD TRANSPORTATION ENGINEERING DESIGN STANDARDS, 1985

FIGURE 5-2

DESIGN CRITERIA FOR LIMITED MOVEMENT DRIVEWAYS

5.4 Access Management

The goal of access management is to provide adequate access to land development while simultaneously preserving the flow of traffic on the surrounding road system in terms of safety, capacity and speed. Increased development along roadways generate the demand for driveways to serve abutting properties. Without access planning and management, the roadway network will become increasingly congested and safety will be compromised.

Senate Bill No. 361, effective September 1, 2003, amends the Transportation Code to state that a state highway access management plan does not surpass a city's rule. In other words, S.B. 361 prohibits TxDOT endorsement of a city's highway access rules as a stipulation for enforcement of a city's regulations. S.B. 361 is quoted below:

SECTION 1. Section 203.032, Transportation Code, is amended to read as follows:
Sec. 203.032. PRECEDENCE OF COMMISION ORDER. (a) Except as provided by Subsection (b), an [An] order of the commission under Section 203.031 supersedes a conflicting rule or ordinance of a state agency or subdivision of this state or any county or municipality, including a home-rule municipality.
(b) An order of the commission under Section 203.031(a)(2) or (4) does not supersede a conflicting rule or ordinance of a municipality, including a home-rule municipality, unless the United States Department of Transportation Federal Highway Administration notifies the department that enforcement of the municipal rule or ordinance would impair the ability of the state or the department to receive funds for highway construction or maintenance from the federal government.
(c) Subsection (b) does not apply when the department owns the access rights.

Table 5-3 provides spacing requirements for TxDOT frontage roads and Table 5-4 provides spacing requirements for other TxDOT highways. This information was obtained from TxDOT's Access Management Manual, which was dated December 2003 and became effective on January 1, 2004. Consideration should be given to the use of these criteria along TxDOT roadways. The City Engineer shall have discretion as to the use of these spacing criteria over the City's criteria, outlined in Tables 5-1 and 5-2, where high speeds, high traffic volumes, unusual geometric conditions, and safety are of concern.

Table 5-3
Minimum Driveway Spacing Criteria for Frontage Roads [(1)]

Posted Speed (mph)	Minimum Connection Spacing (feet)	
	One-Way Frontage Roads	Two-Way Frontage Roads
< 30	200	200
35	250	300
40	305	360
45	360	435
> 50	425	510

Source: TxDOT's Access Management Manual, December 2003

(1) Distances are for passenger cars on level grade. These distances may be adjusted for downgrades and/or significant truck traffic. Where present or projected traffic operations indicate specific needs, consideration may be given to intersection sight distance and operational gap acceptance measurement adjustments.

Table 5-4
Minimum Driveway Spacing Criteria for Other State Highways [(1)(2)]

Posted Speed (mph)	Distance (feet)
30	200
35	250
40	305
45	360
50	425

Source: TxDOT's Access Management Manual, December 2003

(1) Distances are for passenger cars on level grade. These distances may be adjusted for downgrades and/or significant truck traffic. Where present or projected traffic operations indicate specific needs, consideration may be given to intersection sight distance and operational gap acceptance measurement adjustments.

(2) Access spacing values shown in this table do not apply to rural highways outside of metropolitan planning organization boundaries where there is little, if any, potential for development with current ADT levels below 2,000. Access spacing below the values shown in this table may be approved based on safety and operational considerations as determined by TxDOT.

6.1 General

By definition, traffic calming measures are designed to slow or impede traffic and introduce inconvenience to the motorist in order to raise awareness or adjust behavior. As a result, traffic calming measures can have a substantial impact on the function of the roadway system and driver/resident satisfaction. Use of a formal traffic calming process ensures that the most appropriate devices are utilized in a manner that responsibly meets the needs of the driver and surrounding uses.

6.2 Limitation of Devices

The number of appropriate traffic calming devices declines as the scale and purpose of a roadway increases. Generally, traffic calming devices are designed to address issues along local and collector roadways – streets in which excessive speed and volume impede functions such as site access and pedestrian activity. Devices available to arterials and collectors with greater than two lanes should be limited to very low impact horizontal deflection (such as rumble strips) and vertical deflection (such as slight curve serpentines) devices, psychoperceptive devices (such as street trees), signage, education and enforcement activities. Use of horizontal or vertical deflection devices should be increasingly discouraged as the scale of the roadway increases.

6.3 Proactive Traffic Calming

Proactive design is recognized as a viable means of addressing speed and safety issues before they occur. For example, narrow travel lanes make a motorist less comfortable, increase awareness and reduce speeds. Limited street length between interruptions such as intersections increase connectivity, reduce speed and disperse traffic. Analysis of subdivision and roadway design should be used to anticipate and address the possibility of speed or safety issues. Design of narrow lanes may require a waiver from standard design practices.

6.4 Area of Consideration

When possible and appropriate, traffic calming strategies should be developed on a scale greater than a single street segment to account for impacts derived from/or exhibited on surrounding areas. Generally, traffic calming is recommended at the scale of the surrounding neighborhood. If a street segment is determined to be sufficient, consideration should be given to immediately surrounding streets and uses.

6.5 Project Qualification

Prior to significant expenditure of funds collecting data and conducting a traffic calming study, staff should utilize several simple criteria for qualification. Criteria may include previous efforts to qualify a roadway or neighborhood, type of roadway, or observation of local conditions.

6.6 Data Collection

Specific studies aid in confirming problems and also provide information needed to determine the effectiveness of a traffic calming plan. Before and after studies appropriate to the potential problem (such as traffic counts for volume issues or origin-destination studies for cut-through traffic) should be used to first confirm and measure the extent of proposed problems and second, to measure the effectiveness of a traffic calming plan. Other information such as roadway width, lane width, turn radii, collision data, land use, location of crosswalks can aid in determining problems and establishing considerations for device selection.

6.7 Traffic Calming Warrants

Determination of traffic warrants should be based upon presence of high speed, high volume, significant cut-through traffic, or collisions. Pedestrian related collisions may be utilized as additional or alternate criteria. Once warrants are established, priority among sites requiring traffic calming should be determined. Severity of topics utilized to determine warrants is an appropriate measure for determining priority. Other features to consider may include the number of significant traffic generators, street length, distance between intersections, and overall land use.

6.8 Traffic Calming Plan

All traffic calming activities should be developed through a formal planning process that includes opportunities for public participation, distinct measures of effectiveness, understanding of constraints, and selection of coordinated and most appropriate devices.

6.8.1 Public Participation

Development of a traffic calming plan is strongly recommended to include active public participation. Participation in planning can include a public process for complaints, citizen committees that propose measures, public meetings, and follow-up surveys for acceptance. As a general rule, approximately 80 percent approval for installation of traffic calming is recommended to justify traffic calming measures.

6.8.2 Measures of Effectiveness

Success of a traffic calming plan should be based upon measures of effectiveness. Separate measures of effectiveness should be determined for each issue or problem that must be addressed in the traffic calming plan. Measures should be specific according to quantifiable impact and time period. Generally, effectiveness is not fully known within the first year of installation.

6.8.3 Constraints

Constraints represent certain conditions that must be met or that otherwise must be taken into consideration prior to development of a plan. Constraints may include such items as specified emergency routes, parking that needs to be kept, limited right-of-way, and location of major destinations along a roadway.

6.8.4 Device Selection

Selection of a device to address a specific problem should be based upon the device's ability to meet criteria or site conditions. In many cases, a combination of devices may be most appropriate. Considerations in selecting a traffic calming device may include:

1. improvement to overall safety
2. improvement to pedestrian safety
3. ability to reduce speed
4. ability to reduce volume
5. ability to reduce collisions
6. improvement to surrounding environment
7. restrictions upon access
8. impact upon emergency response
9. need for enforcement
10. maintenance costs and requirements
11. impact on noise and pollution
12. installation costs
13. opportunity for violation
14. classification of road
15. desired speed
16. desired traffic flow
17. width of roadway
18. sight distance
19. loss of parking

6.8.5 Plan Development Alternatives & Selection

Plan selection is most effective when chosen from a series of alternatives. Public participation in selection of the preferred alternative may be appropriate, assuming that considerations such as maintenance and cost of installation have already been addressed by the City Engineer.

6.9 IMPLEMENTATION

Prior to full implementation, the City Engineer may opt to install temporary devices to measure potential effectiveness in a more cost effective manner. Likewise, implementation may include a series of stages beginning with less intrusive measures such as education and enforcement to determine if more cost effective measures provide the needed measure of success.

7.1 General

There is a wide range of facility improvements which can enhance bicycle and pedestrian transportation. Improvements can be simple and involve minimal design consideration (such as changing drainage grate inlets) or they can involve a detailed design (such as constructing a hike and bike trail). The major feature of the design for a bicycle or pedestrian facility is its location (i.e., whether it is on a roadway or follows its own independent alignment). Roadway improvements such as bicycle lanes depend on the roadway's design. On the other hand, multi-use paths are located on independent alignments; consequently, their design depends on many factors, including the performance capabilities of the wheeled vehicles and the pedestrians and the volume and mix of the user groups.

With proper planning and design, roadway improvements for motor vehicles can also enhance bicycle and pedestrian travel, and, in any event, should avoid causing adverse impacts on bicycling and walking. A community's overall goals for transportation improvements should, whenever possible, include the enhancement of bicycling and consider the needs for pedestrian movement.

7.2 Design Standards

All bicycle and pedestrian facilities should meet the minimum standards recommended by the American Association of State Highway and Transportation Officials (AASHTO) in the publication Guide for the Development of Bicycle Facilities, 1999, or its most current edition. A similar guide will soon be published by AASHTO for the development of pedestrian facilities. Additional guidance for on-street bicycle facilities is contained in Publication No. FHWA-RD-92-073 Selecting Roadway Design Treatments to Accommodate Bicycles, prepared by the Federal Highway Administration (FHWA) in 1994. Pavement striping, signage, and signals should be in accordance with the most current Texas Manual on Uniform Traffic Control Devices (TMUTCD). Hike and bike trails and sidewalks should be accessible and traversable by physically disabled persons and should comply with the guidelines set forth by the American with Disabilities Act of 1990 (ADA), as enforced in Texas by the Architectural Barriers Section of the Texas Department of Licensing and Regulation. A Best Practices Design Guide, Designing Sidewalks and Trails for Access, Publication N. FHWA-EP-01-027, was published by the Federal Highway Administration in 2001 to disseminate the current state of the practice as desired by the United States Architectural and Transportation Barriers Compliance Board, also known as the U.S. Access Board, in its ADA Accessibility Guidelines (ADAAG) and adopted as standards for design by the U. S. Department of Justice.

7.2.1 Facility Types

The types of facilities that may be provided for bicycle mobility include shared roadways, bicycle routes, wide curb lanes as a special class of bicycle routes, shoulder bikeways, bicycle lanes, and multi-use paths. Pedestrians make use of multi-use pats and sidewalks.

7.2.1.1 Shared Roadway: Because a bicycle is a vehicle, any roadway (except limited access highways, freeways, and others specifically prohibiting bicycle traffic) may be considered part of the on-road bicycle network. Because existing roads typically offer the most direct

route to many destinations, they tend to be favored by advanced or experienced riders. Local streets that are built to the minimum standard 27 feet wide, curb to curb, and carry only low volume, low speed traffic are generally suitable for all cyclists.
On-street parking along local streets in residential areas is compatible with bicycle use, although parking may be a conflict along streets in commercial areas. Drainage grates throughout the city should be positioned with the metal bars perpendicular to the flow of traffic to ensure that bicycle tires do not become lodged in the grate.

7.2.1.2 Bicycle Route: Shared roadways designated as Bike Routes should be signed using standard MUTCD signage. Such designations are used to denote streets that can see significant bicycle usage or are a link in the bikeway network. Designation and improvement as a bike route may warrant a higher level of street maintenance than a shared roadway.

7.2.1.3 Wide Curb Lane - The standard width considered desirable for an outside traffic lane to safely accommodate bicycle <u>and</u> motor vehicle traffic is 14 feet, with an optimum width of 15 feet. This distance is typically measured from the curb face to the lane stripe, but the lane should be wide enough to allow safe passage for cyclists around obstacles such as drainage grates, parked cars, and longitudinal ridges between the pavement and curb and gutter. Lanes wider that 15 feet may encourage use by two motor vehicles and are not conducive to safe cycling.

To create on-road conditions amenable to bicycling, a wide right-hand lane of 14 to 15 feet width should be adopted as a standard design section for non-residential streets. The current standard 27 foot wide residential street is adequate for bicyclists to coexist with local traffic. On multi-lane roadways, a wider, 14 to 15 foot, right-hand lane should be provided depending on prevailing traffic conditions. A good guideline for determining when a wide curb lane is necessary is contained in the manual "<u>Selecting Highway Design Treatments to Accommodate Bicycles,</u>" developed for FHWA by the Bicycle Federation of America and Center for Applied Research, Inc., and funded in part by the State of Texas.

7.2.1.4 Shoulder Bikeway - Advanced (Group A) and recreational (Group B/C) bicycle riders who commute long distances or ride for sport or recreation can safely make use of smooth, paved roadway shoulders, where available. Shoulders should be 6 to 8 feet wide as a standard, but may be a minimum of 4 feet wide in constrained situations. Shoulders should be paved, all-weather surfaces with no ridges, seams or other obstructions.

7.2.1.5 Bicycle Lane - Bike lanes are recommended for streets with motor vehicle speeds greater than 35 mph or with average daily traffic (ADT) volumes greater than 10,000 vehicles per day. Bike lanes are a marked portion of the roadway that is designated for exclusive use by bicycles. Typically, bike lanes may be established on arterials and other major streets where bicycle use exceeds 50 bikes a day.

The standard width for a bike lane is 5 feet for one rider. The minimum width is 4 feet, in accordance with AASHTO. A bike lane between on-street parking and a motor vehicle travel lane should be 5 feet wide, minimum. Lanes wider than 6 feet may encourage parking or other inappropriate uses.

Bike lanes should be signed and marked with an 8-inch wide stripe in accordance with the Texas MUTCD and AASHTO standards. As vehicles, bicycles must ride with the flow of traffic. Bike lanes, therefore are always one-way and should be clearly marked as such. Curbs, raised pavement, or raised buttons are generally not recommended for use as bike lane markings, since they are a safety hazard to cyclists.

7.2.1.6 Multi-use Path - A multi-use path is physically separated from roadways by open space or a barrier. It may be within the roadway right-of-way, a utility right-of-way, or an independent right-of-way. These facilities are sometimes referred to as bike trails or hike and bike trails. Paths that pass in close proximity to residential or commercial development or provide high levels of recreational activity can be expected to be multiple use trails. Conflicts between cyclists and skaters, joggers, pedestrians, animals, and less experienced cyclists should be anticipated and considered in appropriate design.

Paths should be 10 to 12 feet wide, as a desirable standard depending upon activity levels, with a minimum width of 8 feet. Maintenance vehicles driving on 8 foot wide paths tend to damage the edges. Therefore, 8 foot paths should be avoided unless physical limitations cannot accommodate a greater width and relatively sparse use is anticipated. Paths with anticipated high activity levels should be 12 feet wide or greater, potentially providing separate pathways for bicyclists and pedestrians (wheels and heels). Such a wide path should transition to 10 feet in width, combining any separation, in the vicinity of an intersection crossing. One-way bike paths are difficult to police and should be avoided, if possible. Where they are used, they should be clearly signed and/or marked as one-way, with a standard width of 6 feet and a minimum width of 5 feet.

Multi-use paths should have an additional 2 feet of smoothly graded area on either side of the pavement. In addition, there should be 3 feet of horizontal and 10 feet (8 feet minimum) of overhead clearance on either side of the pavement.

Multi-use paths should be constructed of smooth, hard, all-weather paving such as concrete or asphalt. Although more expensive, concrete paths require less maintenance than asphalt paths, which can buckle, crack, and erode quickly, especially along waterways. Good maintenance is essential for bike paths to eliminate and avoid hazardous conditions. Compacted granular surfaces are more difficult to use for many user groups, thus should be relegated to specific jogging or other special use trails.

Path slopes should comply with current requirements of the Americans with Disabilities Act Accessibility Guidelines (ADAAG). The maximum running grade for paths is 5 percent and changes in slopes should be kept as gradual as possible, with a total change in grade of not more than 11 percent unless provided with a transition (e.g a sag curve or intermediate slope). When grades must exceed five percent, the total running slope should not exceed 8.3 percent for over 30 percent of the path and other path attributes of cross slope and width should meet desired standards. Slopes over 5 but less than 8.3 percent can be maintained for a maximum of 200 feet, before a landing of less than 2 percent slope should be provided. Very short ramps can exceed the 8.3 percent maximum slope, but are used only for severe design constraints and obstacles. Paths immediately adjacent to a roadway may match the slope of the roadway if such is the constraint, but should incorporate intermediate landings where possible and larger landings at terminal points.

Cross slopes on paved paths are generally about 2 percent for drainage, but often accommodate driveway or other crossing or terrain elements that result in steeper grades. For running grades of up to 5 percent, path cross slopes of up to 8 percent are tolerable for short distances such as across a driveway. For running grades of 8 percent, cross slopes should be kept below 5 percent. For long distances, cross slopes should not be greater than 3 percent. Changes in cross slopes should be kept as gradual as possible, as abrupt changes can have and stabilizing impact on wheelchair users.

Curb cuts and ramps for access to paths should be provided at all street intersections with the bike path. Curb cuts for paths should be a minimum of 8 feet wide.

Use of a Y-intersection, with the trail splitting into two one-way sections of narrower width, is a good way to transition a bike path to an on-street facility. Proper alignment of the one-way segment with the receiving roadway encourages the mental transition of the cyclists from off-road to on-road behavior. Road crossings should be perpendicular to, and generally close to, the intersection, especially at a signalized intersection with a multi-lane roadway.

7.2.1.6 Sidewalks - A sidewalk is physically separated from an adjacent roadway by open space, a curb or a barrier. It can be paved or unpaved, though a majority of sidewalks are paved with concrete. Public sidewalks generally are placed parallel to a roadway within the public right-of-way for a street corridor. The space between the edge of the roadway and the edge of the right-of-way is typically shared by sidewalk pavement, sign posts, utility lines and fixtures, and landscaping, and any street furniture such as benches, mailboxes and the like. Sufficient space should be allocated beyond the edge of pavement for all planned improvements.

The total width of the sidewalk corridor beyond the face of curb or edge of pavement of the roadway should be thought of in terms of three separate zones:

1. <u>The landscape/furniture zone</u> – This area will need to be wide enough to contain all needed street signs, landscaping and any benches, bus stop shelters and street lighting. The width of this zone should be at least 2 feet, not including the width of the curb, to buffer the pedestrian zone from the travel lanes. When parking is provided between the travel lane and the pedestrian zone, the 2-foot minimum

width is needed for a buffer against opening car doors. This zone can be completely paved if so desired. When landscaping is planned for this zone, a minimum of 4 feet should be provided.

2. The pedestrian zone - This zone should be a minimum of 5 feet in width. For very active pedestrian areas, such as in the downtown area and adjacent to school campuses, this zone width should be increased to a minimum of 8 feet. Should an obstacle in the pedestrian zone be unavoidable, there must be a minimum of 36 inches of passable space throughout this zone. Any utility access covers in the zone should be set flush with the pavement and maintained as such, with slip-resistant cover plates and any openings smaller than one-half inch diameter.
3. The frontage zone – This zone provides needed buffer between the pedestrian zone and obstacles at the property edge. For sidewalks adjacent to parks, property setbacks and other permanent open space, this zone can be eliminated. For fence lines and building edges placed on the property line, a minimum of 1 foot should be provided for this zone. Vegetation along the property edge should be required to be trimmed back off the pubic right of way by the adjacent property owner. For sidewalks along storefronts with doors opening into the sidewalk corridor, two feet of width should be provided.

Utility requirements should be considered in regard to how they will be placed within each of these three zones, and any specific space requirements added to the overall width of the sidewalk corridor.

Slope requirements are as stated for multi-use paths, but become more crucial for the sidewalk environment. Ramps at intersections should direct the pedestrian toward the receiving sidewalk corridor on the opposite side of the street, regardless of whether a sidewalk has been paved.

7.2.2 Roadway Intersection Design

Roadway intersection design should include accommodations for bicycles and pedestrians.

7.2.2.1 Intersection Design for Bicycles - Statistical studies of bicycle-motor vehicle and pedestrian-motor vehicle accidents have indicated that a majority of these accidents occur at or near roadway intersections. Proper design of intersections to better accommodate cyclists and pedestrians must be introduced along with education of cyclists on how to properly position themselves and behave to proceed safely through the intersection. For the roadway designer, a number of sources are available to provide guidance on the proper design of roadways to accommodate bicyclists. One excellent course of instruction on Bicycle Facility Planning and Design is offered by Northwestern University Traffic Institute (Mr. Alex Sorton (708) 409 - 5040). The primary need is to get the roadway designer to include consideration of the bicyclist and pedestrian in the design of the roadway; whether a designated bikeway is planned or not. An individual trained in the planning and design of bicycle and pedestrian facilities should be designated to review all roadway and intersection designs for street and highway improvements planned by developers, the City and TxDOT.

7.2.2 2 Intersection Design for Pedestrians – The design of safe roadway crossings for pedestrians is contained in many technical publications including A Policy of Geometric Design of Highways and Streets, last published in 2001 by AASHTO and Design and Safety of Pedestrian Facilities, published in 1998 by the Institute of Transportation Engineers. The previously sited Designing Sidewalks and Trails for Access is a primary guideline to assure ADA compliance for access and mobility by physical, visual or hearing impairments. Current crosswalk design practices call for sidewalk ramps directed across the street to the opposing sidewalk ramp and no longer allow the corner ramp that directs visually impaired pedestrians into the middle of the intersection.

Intersection crossing distances should be minimized as much as possible by adding bulb-outs at corners where curbside parking is allowed, providing auxiliary turn lanes only where absolutely needed, and adding pedestrian refuge islands to break up unprotected crossing distances to not more than 48 feet where possible. Pedestrian refuge islands should be provided with a minimum width of 8 feet. At signalized intersections, the installation of count-down indicators informs the crossing pedestrian of how many seconds remain before crossing traffic is given the green, which helps relieve the stress pedestrians feel when crossing in front of queued traffic.

7.2.3 Traffic Signals

Issues regarding traffic signals are recommended to be addressed by the City's engineering staff. These include minimum green time, amber clearance time, and signal detectors.

7.2.3.1 Minimum Green Time for Bicycles – Due to the slower start-up and acceleration characteristics of bicycles, traffic signals at some minor street crossings of major arterials, especially when operating as an actuated phase, need to have a minimum green indication of approximately 7 to 10 seconds to accommodate bicyclists, depending on the approach conditions.

7.2.3.1 Amber Clearance for Bicycles – The amount of time the yellow or amber signal indication is displayed as part of a signal sequence typically varies from 3 to 5 seconds depending on the approach speed of vehicular traffic and the width of the intersection. For some of the wider street sections, bicyclists crossing with the signal may need to be allowed a longer clearance interval (including all red) to keep from being hit by motorists (illegally) leaving the stop line on the far side.

7.2.3.2 Signal Detectors for Bicycles – To bring up an actuated signal phase, a detector mechanism needs to be tripped by an approaching vehicle. The older trip-bars could not be actuated by a bicycle and are fortunately being phased out and remaining installations are rare. Due to the scarcity of metals in the bicycle and the configuration of the bicycle, in-pavement detector loops often do not sense the arrival of a bicycle. The straight slender bicycle passes across the end wires of the loop parallel to the field created and often does not sufficiently interrupt the electro-magnetic field of the loop detector to actuate the signal phase. Riding over the side wires crosses perpendicular to the field and will be detected. The Texas Transportation Institute (TTI) has investigated this issue for the Texas Department of Transportation, and has proposed some solutions. As reported in TTI Research Report 1163-3F, the researchers found that simply cutting into the pavement a parallelogram with the end wires at a 45-degree angle, rather than the basic rectangular shape, will detect bicyclists crossing the end wires at an angle, thus better interrupting the electro-magnetic field and actuating the traffic signal. Pavement markings to highlight the detector loop can also serve to inform cyclists of how to position themselves to actuate the signal.

7.2.3.3 Signal Crossing Facilities for Pedestrians – The safe design of signals at crossings for pedestrians is contained in many technical publications including Design and Safety of Pedestrian Facilities , published in 1998 by the Institute of Transportation Engineers. A new treatment that facilitates safety of crossing pedestrians, particularly those that move slower than average, is the count-down display that indicates how many seconds of safe crossing time remain. Another important reference to assure ADA compliance for access and mobility by physical, visual or hearing impairments is Building a True Community, prepared by the Public Rights-of-Way Access Advisory Committee and published by the U.S. Architectural and Transportation Barriers Compliance Board. Audible signals and tactile devises on the pavement and signage facilitate crossing by visually impaired persons.

7.2.4 Signage and Striping for Bicycle Facilities

Signs and pavement markings for bicycles encourage use and advertise the bicycle as a vehicle on the road. They help legitimize the presence of bicycles in the eyes of motorist and potential bicyclists. All signage and lane striping should be in general accordance with the latest edition of the Texas Manual of Uniform Traffic Control Devices (TMUTCD).

7.2.4.1 Signage – The basic bike route sign should be used on all local designated bike routes. For the longer regional routes, the numbered bikeway sign should be utilized. One scheme used in some cities is to number bike routes sequentially east to west and north to south, with north-south routes having odd numbers and east-west routes having even numbers.

7.2.4.2 Special signs have been developed by other communities. – Most notable is the "SHARE THE ROAD" warning sign for on-street facilities. Some communities, such as Dallas, have even placed a special logo or shape on their route designation signage. Austin has developed a "share the road" sign using a State of Texas color scheme and capital building silhouette. The regional numbered bike route signs would also be good candidates for a specially designed sign.

7.2.4.3 Striping – Striping of bike lanes should be in conformance to the TMUTCD, Part IX. All bike paths that are 10 feet wide or greater should receive a yellow centerline stripe.

7.2.4.4 Rumble Strips – Rumble strips are raised or grooved patterns on the road shoulder that provide both an audible and physical vibration that alert drivers that the are leaving the road. They alert non-attentive motorists that they have drifted outside the travel lane, and can be an effective countermeasure to help prevent over one-third of all fatalities on our highways, which are due to run off the road occurrences. The FHWA is currently completing review of national standards for rolled, milled and raised rumble strips.

7.2.4.5 Roadway shoulders provide an excellent location for bicyclists to traverse higher volume and rural roadways. Rumble strips take up a portion of the available shoulder with for bicyclists. Rumble strips on the shoulders of roadways should only be placed on long-haul freeways where driver fatigue and inattention are a significant factor. Rumble strips should be kept to within two feet of the outside lane edge line, and should only be placed on shoulders with a minimum width of eight feet.

7.3 Other Supporting Facilities and Programs

7.3.1 Bicycle Parking

Bicycle parking should be provided, by ordinance, at all public buildings which are potential cyclist destinations. Bicycle parking should be encouraged, potentially by ordinance, at privately owned facilities which are potential bicyclist destinations.

There are two basic types of bicycle parking equipment: bicycle racks and bicycle lockers. Bicycle racks may be provided where parking needs are short term and some provisions are made for security or surveillance. Lockers would be desired for all-day parking if the location is remote from the destination and where the desired level of security is higher than that provided.

The design of bicycle racks is most useful for cyclists since the bicycle frame and wheels can be secured to the rack structure. Many types of bicycle racks are currently available, ranging from the basic wheel-engaging schoolyard type, to the more functional U-shapes or ribbon rails, to the "bike traps" with moveable segments to lock the bike in place. Prices of bike racks can range from $20 per space to over $200 per space.

Bicycle lockers are physical enclosure for bicycle, typically in individual compartments. They require a paved structure for mounting and require more physical space than a fully occupied bike rack of the same capacity. Costs of locker installation can range from $200 to over $500 per space, depending on the quantities and type of facility.

7.3.2 Bicycles and Transit

The ability to link trips made by bicycle with bus trips provides significant expansion of the service area for bus routes and also increases the utility of bicycles as a travel mode. The Capital Area Regional Transportation System (CARTS) and the university's student bus service should improve their bus fleets and bus stop facilities to accommodate bicycles. Bike racks or lockers at bus stops and bike carriers on buses will enable cyclists to combine trips by bus and bicycle, increasing the range of service area and promoting the use of both modes independently and collectively.

7.3.3 Maintenance

Bicycle and pedestrian facilities should be maintained to ensure the safety and functionality of bicycle and pedestrian flows. Periodic refurbishing and debris removal will help keep original design concepts intact. The degree of maintenance provided has a direct impact facility service life, effectiveness, level of use, liability and community image. Poor facility maintenance coveys a feeling of lack of security and fear for personal safety, often resulting in decreased facility usage with a possible increase in bicycle and pedestrian accidents elsewhere due to the use of alternative, less safe routes.

7.3.4 Sidewalk Continuity

In the interest of providing safe and alternative modes of transportation for bicyclists and pedestrians, and to encourage the construction of continuous sidewalk throughout the City, sidewalks should be required to be continuous. Where an undeveloped lot of not more than 500 feet of street frontage is located between two developed lots, and where the sidewalk on either side of the undeveloped lot has a length longer than 200 feet, and where the continuity of the sidewalk is desired by the City for connecting pedestrians to activity centers, then City may notify the property owner identified on the current tax roll that the owner shall be responsible for construction of the sidewalk within the ensuing two (2) years, or in lieu of the construction of the sidewalk, the property owner shall place into an interest bearing escrow account within a period of two years the amount equal to the cost of constructing said sidewalk. The City shall then use such funds to construct the sidewalk within a period of 5 years. If the sidewalk is not constructed within 5 years, the funds shall be returned to the property owner of record with interest.

7.3.4 Corner Cuts

There is an inherent difficulty in the placement of needed sidewalk ramps, and traffic control devices at corners, due to the fact that property corners come to a point and roadway curb lines are curved inward at the corners. Even the smallest of corner radii trim the sidewalk space to a minimum at the corner. Often there is little or no space for street lamps, power poles, signal poles, signs and a host of other implements that need t be as near to the corner as possible.

To provide the needed space to place these needed implements at the corners of street intersections, a corner cut requirement should be implemented for the intersections of significant roadways. When street widths are dedicated as part of development, a triangular piece of the corner properties should be acquired as well, measured back along each intersecting street as follows:

- For collector streets intersecting collector streets or for local or collector streets requiring a corner radius of more than 15 feet, a 5-foot corner cut should be acquired (measuring 5′ x 5′ x 7.1′ equal to 12.5 square feet of property)
- For collector streets intersecting arterial streets, a 7-foot corner cut should be acquired (measuring 7′ x 7′ x 9.9′ equal to 24.5 square feet of property)

- For arterial streets intersecting arterial streets, a 10-foot corner cut should be acquired (measuring 10' x 10' x 7.1' equal to 50 square feet of property)

8.1 General

When designing a street or a complete integrated roadway network, consideration should be given to potential utilization of transit vehicles and transit operation. The Transit Facility Design Guide, attached in Appendix A, was developed by the Center of Transportation Research, to facilitate the use of transit of vehicles and operation into a roadway network.

1. American Association of State Highway Transportation Officials', A Policy on Geometric Design of Highways and Streets, Washington, D.C., 2001.

2. American Association of State Highway Transportation Officials', Pavement Design Guide, Washington, D.C., 2002.

3. American Association of State Highway Transportation Officials', Roadside Design Guide, Washington, D.C., 1996.

4. City of San Marcos, Manual for Design and Construction, Adopted 1998.

5. City of San Marcos, San Marcos City Code, Adopted 1995.

6. City of Austin, Transportation Development Criteria Manual, Adopted 1998.

7. City of Austin, Drainage Criteria Manual, Adopted 1998.

8. City of Georgetown, Unified Development Code, Adopted March 11, 2003, Effective March 26, 2003.

9. City of San Antonio, Unified Development Code, Updated May 2001.

10. Institute of Transportation Engineers, Guidelines of Urban Major Street Design, Washington, D.C., 1983.

11. Illuminating Engineering Society, Practice for Roadway Lighting PR-8, American National Standards Institute, 1983.

12. Lin, Han-Jei, Machemaehl, Clyde E.Lee, and Herman, Robert, Guidelines for Use of Left-turn Lanes and Signal Phased, Research Report 258-1, University of Texas Center for Transportation Research, Bureau of Engineering Research, The University of Texas at Austin, 1984.

13. Metropolitan Transit Authority of Harris County, Texas, Uniform Design Standards Manual

14. NCHRP Report 93, Transportation Research Board, Washington, D.C., 1970.

15. Texas Department of Transportation, Texas Manual on Uniform Traffic Control Devices, 2003.

16. Texas Department of Transportation, Access Management Manual, 2003.

17. Texas Department of Transportation's Austin District Standards and Specifications.

18. Walton, N.E. and N.J. Rowan, Warrants for Highway Lighting, NCHRP Report 152, Transportation Research Board, Washington, D.C., 1974.